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DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS

RST-15650R (March 2002)

Superseding
RST-15650R (August 2000)
CEGS-15650 (July 1992)
CEGS-15650 (August 1990)

GUIDE SPECIFICATION FOR CONSTRUCTION

Specification revised to meet U.S. Army Reserve requirements (March 2002)
Includes Special Change (Submittal Paragraph)(June 2000)
Includes changes through Notice 14 (Mar 2000)
Includes note relocation Special change (August 1995)
Includes Text Adjustment Change (Section Reference)(June 1997)

Latest change indicated by CHG tags

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DIVISION 15 - MECHANICAL

SECTION 15650R

CENTRAL REFRIGERATED AIR-CONDITIONING SYSTEM

03/02

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SECTION 15650R

CENTRAL REFRIGERATED AIR-CONDITIONING SYSTEM
03/02

NOTE: This guide specification covers the requirements for chilled water applications. This guide specification is to be used in the preparation of project specifications in accordance with ER 1110-1-8155.

Comments and suggestions on this guide specification are welcome and should be directed to the proponent of the specification. A listing of proponents, including their organization designation and telephone number, is at URL http://www.hnd.usace.army.mil/techinfo/index.htm, and an electronic feedback page for submission of recommended changes is available at the same address. Use of electronic communication is encouraged.

NOTE: RST-15650 is a Louisville District Army Reserve Support Team (RST) version of CEGS-15650. Any text changed by the RST is underlined. Refer all specification comments to the RST

PART 1 GENERAL

1.1 REFERENCES

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NOTE: Issue (date) of references included in project specifications need not be more current than provided by the latest change (Notice) to this guide specification.

****

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AIR CONDITIONING AND REFRIGERATION INSTITUTE (ARI)

ARI 450	(1999) Water-Cooled Refrigerant Condensers, Remote Type
ARI 460	(1994) Remote Mechanical-Draft Air-Cooled Refrigerant Condensers
ARI 480	(1995) Refrigerant-Cooled Liquid Coolers, Remote Type
ARI 495	(1999) Refrigerant Liquid Receivers
ARI 550	(1992) Centrifugal or Rotary Screw Water-Chilling Packages
ARI 560	(1992) Absorption Water Chilling and Water Heating Packages
ARI 575	(1994) Method of Measuring Machinery Sound Within an Equipment Space
ARI 590	(1992) Positive Displacement Compressor Water-Chilling Packages
ARI 700	(1995; Apx C) Specifications for Fluorocarbon and Other Refrigerants
ARI 710	(1995) Liquid-Line Driers
ARI 720	(1997) Refrigerant Access Valves and Hose Connectors
ARI 740	(1998) Refrigerant Recovery/Recycling Equipment
ARI 750	(1994) Thermostatic Refrigerant Expansion Valves
ARI 760	(1994) Solenoid Valves for Use with

Volatile Refrigerants

AMERICAN BEARING MANUFACTURERS ASSOCIATION (AFBMA)

AFBMA Std 9	(1990) Load Ratings and Fatigue Life for Ball Bearings
AFBMA Std 11	(1990) Load Ratings and Fatigue Life for Roller Bearings

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI S1.13	(1995) Methods for the Measurement of Sound Pressure Levels

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 47	(1990; R 1995) Ferritic Malleable Iron Castings
ASTM A 47M	(1999) Ferritic Malleable Iron Castings (Metric)
ASTM A 48	(1994a) Gray Iron Castings
ASTM A 48M	(1994el) Gray Iron Castings (Metric)
ASTM A 53	(1999b) Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A 106	(1999el) Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A 123/A 123M	(1997ael) Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A 153/A 153M	(1998) Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A 181/A181M	(1995b) Carbon Steel Forgings for General-Purpose Piping
ASTM A 183	(1983; R 1998) Carbon Steel Track Bolts and Nuts
ASTM A 193/A 193M	(1999) Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service
ASTM A 234/A 234M	(1999) Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
ASTM A 307	(1997) Carbon Steel Bolts and Studs, 60

	000 PSI Tensile Strength
ASTM A 334/A 334M	(1999) Seamless and Welded Carbon and Alloy-Steel Tubes for Low-Temperature Service
ASTM A 536	(1999el) Ductile Iron Castings
ASTM A 733	(1999) Welded and Seamless Carbon Steel and Austenitic Stainless Steel Pipe Nipples
ASTM B 32	(1996) Solder Metal
ASTM B 62	(1993) Composition Bronze or Ounce Metal Castings
ASTM B 75	(1997) Seamless Copper Tube
ASTM B 75M	(1997) Seamless Copper Tube (Metric)
ASTM B 88	(1996) Seamless Copper Water Tube
ASTM B 88M	(1996) Seamless Copper Water Tube (Metric)
ASTM B 117	(1997) Operating Salt Spray (Fog) Apparatus
ASTM B 280	(1998) Seamless Copper Tube for Air Conditioning and Refrigeration Field Service
ASTM B 650	(1995) Electrodeposited Engineering Chromium Coatings on Ferrous Substrates
ASTM B 813	(1993) Liquid and Paste Fluxes for Soldering Applications of Copper and Copper Alloy Tube
ASTM C 67	(1998a) Sampling and Testing Brick and Structural Clay Tile
ASTM C 534	(1999) Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form
ASTM D 520	(1984; R 1995el) Zinc Dust Pigment
ASTM D 596	(1991; R 1995) Reporting Results of Analysis of Water
ASTM D 1384	(1997a) Corrosion Test for Engine Coolants in Glassware
ASTM D 1784	(1999a) Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl

	Chloride) (CPVC) Compounds
ASTM D 2000	(1999) Rubber Products in Automotive Applications
ASTM D 3308	(1997) PTFE Resin Skived Tape
ASTM E 84	(1999) Surface Burning Characteristics of Building Materials
ASTM F 104	(1995) Nonmetallic Gasket Materials
ASTM F 1199	(1988; R 1998) Cast (All Temperature and Pressures) and Welded Pipe Line Strainers (150 psig and 150 degrees F Maximum)
ASTM F 1200	(1988; R 1998) Fabricated (Welded) Pipe Line Strainers (Above 150 psig and 150 degrees F)

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 15	(1994) Safety Code for Mechanical Refrigeration
ASHRAE 34	(1997) Number Designation and Safety Classification of Refrigerants
ASHRAE 64	(1995) Methods of Testing Remote Mechanical-Draft Evaporative Refrigerant Condensers

ASME INTERNATIONAL (ASME)

ASME B1.20.1	(1983; R 1992) Pipe Threads, General Purpose (Inch)
ASME B16.5	(1996; B16.5a) Pipe Flanges and Flanged Fittings NPS 1/2 thru NPS 24
ASME B16.9	(1993) Factory-Made Wrought Steel Buttwelding Fittings
ASME B16.11	(1996) Forged Fittings, Socket-Welding and Threaded
ASME B16.18	(1984; R 1994) Cast Copper Alloy Solder Joint Pressure Fittings
ASME B16.21	(1992) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.22	(1995; B16.22a1998) Wrought Copper and

	Copper Alloy Solder Joint Pressure Fittings
ASME B16.26	(1988) Cast Copper Alloy Fittings for Flared Copper Tubes
ASME B16.39	(1998) Malleable Iron Threaded Pipe Unions Classes 150, 250, and 300
ASME B31.1	(1998) Power Piping
ASME B31.5	(1992; B31.5a1994) Refrigeration Piping
ASME B40.1	(1991) Gauges - Pressure Indicating Dial Type - Elastic Element
ASME BPV VIII Div 1	(1998) Boiler and Pressure Vessel Code; Section VIII, Pressure Vessels Division 1 - Basic Coverage
ASME BPV IX	(1998) Boiler and Pressure Vessel Code; Section IX, Welding and Brazing Qualifications
ASME PTC 23	(1986; Addenda 1992, R 1997) Atmospheric Water Cooling Equipment

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C606	(1997) Grooved and Shouldered Joints

AMERICAN WELDING SOCIETY (AWS)

AWS A5.8	(1992) Filler Metals for Brazing and Braze Welding
AWS D1.1	(1998) Structural Welding Code - Steel

CALIFORNIA REDWOOD ASSOCIATION (CRA)

CRA RIS-01-SS	(1997) Standard Specifications for Grades of California Redwood Lumber

COOLING TOWER INSTITUTE (CTI)

CTI ATC-105	(1997) Acceptance Test Code
CTI Std-103	(1994) The Design of Cooling Towers with Redwood Lumber
CTI Std-111	(1998) Gear Speed Reducers
CTI Std-112	(1986; R 1997) Pressure Preservative Treatment of Lumber

CTI Std-114 (1996) The Design of Cooling Towers with Douglas Fir Lumber

CTI Std-134 (1996) Plywood for Use in Cooling Towers

CTI Std-137 (1994) Fiberglass Pultruded Structural Products for Use in Cooling Towers

EXPANSION JOINT MANUFACTURERS ASSOCIATION (EJMA)

EJMA Stds (1998; 7th Edition) EJMA Standards

HYDRAULIC INSTITUTE (HI)

HI 1.1-1.5 (1994) Centrifugal Pumps

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-25 (1998) Standard Marking System for Valves, Fittings, Flanges and Unions

MSS SP-58 (1993) Pipe Hangers and Supports - Materials, Design and Manufacture

MSS SP-67 (1995) Butterfly Valves

MSS SP-69 (1996) Pipe Hangers and Supports - Selection and Application

MSS SP-70 (1998) Cast Iron Gate Valves, Flanged and Threaded Ends

MSS SP-71 (1997) Gray Iron Swing Check Valves, Flanges and Threaded Ends

MSS SP-72 (1992) Ball Valves with Flanged or Butt-Welding Ends for General Service

MSS SP-78 (1998) Cast Iron Plug Valves, Flanged and Threaded Ends

MSS SP-80 (1997) Bronze Gate, Globe, Angle and Check Valves

MSS SP-85 (1994) Cast Iron Globe & Angle Valves, Flanged and Threaded Ends

MSS SP-110 (1996) Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(1997) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ICS 1	(1993) Industrial Controls and Systems
NEMA ICS 2	(1993) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated Not More Than 2,000 Volts AC or 750 Volts DC
NEMA MG 1	(1998) Motors and Generators
NEMA SM 23	(1991) Steam Turbines for Mechanical Drive Service

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 37	(1998) Installation and Use of Stationary Combustion Engines and Gas Turbines
NFPA 54	(1996; Errata) National Fuel Gas Code
NFPA 90A	(1996) Installation of Air Conditioning and Ventilating Systems
NFPA 214	(1996) Water-Cooling Towers
NFPA 255	(1996) Method of Test of Surface Burning Characteristics of Building Materials

SOCIETY OF AUTOMOTIVE ENGINEERS (SAE)

SAE J 537	(1996) Storage Batteries

UNDERWRITERS LABORATORIES (UL)

UL 1236	(1994; Rev thru Mar 1999) Battery Chargers for Charging Engine-Starter Batteries

WESTERN WOOD PRODUCTS ASSOCIATION (WWPA)

WWPA Grading Rules	(1999) Western Lumber Grading Rules 95

1.2 SYSTEM DESCRIPTION

This specification section covers the provisions and installation procedures necessary for a complete and totally functional central refrigerated air-conditioning system as defined herein.

1.3 SUBMITTALS

****

NOTE: Submittals must be limited to those necessary for adequate quality control. The importance of an

item in the project should be one of the primary factors in determining if a submittal for the item should be required.

Indicate submittal classification in the blank space following the name of the item requiring the submittal by using "G" when the submittal requires Government approval. Submittals not classified as "G" will show on the submittal register as "Information Only". For submittals requiring Government approval, a code of up to three characters should be used following the "G" designation to indicate the approving authority; codes of "RE" for Resident Engineer approval, "ED" for Engineering approval, and "AE" for Architect-Engineer approval are recommended.

****

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 SHOP DRAWINGS

Central Refrigerated Air-Conditioning System; [____].

Drawings, at least [5 weeks] [____] prior to beginning construction, shall provide adequate detail to demonstrate compliance with contract requirements. Drawings shall consist of:

a. Equipment layouts which identify assembly and installation details.

b. Piping layouts which identify all valves and fittings.

c. Plans and elevations which identify clearances required for maintenance and operation.

d. Wiring diagrams which identify each component individually and all interconected or interlocked relationships between components.

e. Foundation drawings, bolt-setting information, and foundation bolts prior to concrete foundation construction for all equipment indicated or required to have concrete foundations.

f. Details, if piping and equipment are to be supported other than as indicated, which include loadings and type of frames, brackets, stanchions, or other supports.

SD-03 Product Data

Central Refrigerated Air-Conditioning System; [_____].

Manufacturer's catalog data, at least [5 weeks] [_____] prior to beginning construction, shall be highlighted to show model No., size, options, performance charts and curves, etc. in adequate detail to demonstrate compliance with contract requirements. Data shall include manufacturer's recommended installation instructions and procedures. Data shall be adequate to demonstrate compliance with contract requirements as specified within the paragraphs:

a. Refrigeration System
b. System Components
c. Accessories
d. Cooling Tower
e. Piping Components

If vibration isolation is specified for a unit, vibration isolator literature shall be included containing catalog cuts and certification that the isolation characteristics of the isolators provided meet the manufacturer's recommendations.

Water Treatment Systems; [_____].

[Six] [_____] complete copies, at least 5 weeks prior to the purchase of the water treatment system, of the proposed water treatment plan including a layout, control scheme, a list of existing make-up water conditions including the items listed in Paragraph Water Analysis, a list of chemicals, the proportion of chemicals to be added, the final treated water conditions, and a description of environmental concerns for handling the chemicals.

Spare Parts; [_____].

Spare parts data for each different item of material and equipment specified, after approval of the detail drawings and not later than [_____] months prior to the date of beneficial occupancy. The data shall include a complete list of parts and supplies, with source of supply.

Qualifications; [_____].

[_____] copies of qualified procedures, and list of names and identification symbols of qualified welders and welding operators, prior to non-factory welding operations.

****

NOTE: Vendor information that forms part of this guide specification is permissible to use as long as the salient features provide for "or equal" product equivalents are specified. Submittal clauses must be modified to make known that specific vendor information is being specified. If the Contractor chooses to provide the specified vendor's product, the submittal for that item is considered a For

Information Only. If the Contractor uses a different "or equal" item, then it will be evaluated against the salient features. Hence, it is considered for Government Approval (G). The Resident Engineer (RE) will typically perform the approval.

****

Manufacturers products listed in this specification are referenced to establish a standard of quality. When the specific product listed is submitted by the Contractor, that submittal will be considered For Information Only. When an equal to that named in this specification is submitted, it shall be for Government Approval (G). The following manufacturer products are specifically mentioned in this specification:

[CHILLER][CONDENSER]Carrier Corp., Model [_____]; FIO
[CHILLER][CONDENSER]Dunham-Bush, Inc., Model [_____; FIO
[CHILLER][CONDENSER]Snyder General Corp., Model [_____]; FIO
[CHILLER][CONDENSER]Trane Company., Model [_____]; FIO
[CHILLER][CONDENSER]York International Corp., Model [_____]; FIO
[CHILLER][CONDENSER]Manuf. Prod. submitted as an "or equal"; G RE.
COOLING TOWER, Baltimore Aircoil Co., Model [_____]; FIO
COOLING TOWER, Evapco, Inc., Model [_____]; FIO
COOLING TOWER, Marley Cooling Tower Co., Model [_____]; FIO
COOLING TOWER, Manuf. Prod. submitted as an "or equal"; G RE.
DIAPHRAGM-TYPE EXPANSION TANKS, Armstrong Pumps, Inc., Model [_____]; FIO
DIAPHRAGM-TYPE EXPANSION TANKS, Bell & Gossett Corp., Model [_____] ; FIO
DIAPHRAGM-TYPE EXPANSION TANKS, Taco, Inc., Model [_____]; FIO
DIAPHRAGM-TYPE EXPANSION TANKS, Manuf. Prod. submitted as an "or equal"; G RE.

SD-04 Samples

Posted Instructions; [_____].

Posted instructions, at least [2] [_____] weeks prior to construction completion, shall include equipment layout, wiring and control diagrams, piping, valves and control sequences, and typed condensed operation instructions. The condensed operation instructions shall include preventative maintenance procedures, methods of checking the system for normal and safe operation, and procedures for safely starting and stopping the system. The posted instructions shall be framed under glass or laminated plastic and be posted where indicated by the Contracting Officer.

SD-06 Test Reports

Factory Tests; [_____].

Schedules, at least [2] [_____] weeks prior to the factory test, which identify the date, time, and location for each test.

Schedules shall be submitted for both the Chiller Performance Test and the Chiller Sound Test. [The Chiller Performance Test schedule shall also allow the witnessing of the test by a Government Representative.]

Tests; [_____].

Test schedules, at least [2] [_____] weeks prior to the start of related testing, for each of the field tests, the system performance tests, and the condenser water quality tests. The schedules shall identify the date, time, and location for each test.

Demonstrations; [_____].

A schedule, at least [2] [_____] weeks prior to the date of the proposed training course, which identifies the date, time, and location for the training.

Field Tests; [_____].

[Six] [_____] copies of the report shall be provided in bound 216 x 279 mm (8 1/2 x 11 inch) 8 1/2 x 11 inch booklets. Reports shall document all phases of tests performed during the Water Pipe Testing, the Refrigerant Pipe Testing, and the Cooling Tower Tests. The report shall include initial test summaries, all repairs/adjustments made, and the final test results.

System Performance Tests; [_____].

[Six] [_____] copies of the report shall be provided in bound 216 x 279 (8 1/2 x 11 inch) 8 1/2 x 11 inch booklets. The report shall document compliance with the specified performance criteria upon completion and testing of the system. The report shall indicate the number of days covered by the tests and any conclusions as to the adequacy of the system. The report shall also include the following information and shall be taken at least three different times at outside dry-bulb temperatures that are at least 3 degrees C (5 degrees F) 5 degrees F apart:

a. Date and outside weather conditions.
b. The load on the system based on the following:

(1) The refrigerant used in the system.

(2) Condensing temperature and pressure.

(3) Suction temperature and pressure.

(4) For absorption units, the cooling water pressures and temperatures entering and exiting the absorber and condenser. Also the refrigerant solution pressures, concentrations, and temperatures at each measurable point within the system

(5) Running current, voltage and proper phase sequence for each phase of all motors.

(6) The actual on-site setting of all operating and safety controls.

(7) Chilled water pressure, flow and temperature in and out of the chiller.

(8) The position of the [capacity-reduction gear] [gas supply control valve] [fuel oil supply valve] at machine off, one-third loaded, one-half loaded, two-thirds loaded, and fully loaded.

Condenser Water Quality Tests; [_____].

Test reports, each month for a period of one year after project completion, in bound 216 x 279 (8 1/2 x 11 inch) 8 1/2 x 11 inch booklets. The reports shall identifying the chemical composition of the condenser water. The reports shall also include a comparison of the manufacturer's recommended operating conditions for the cooling tower and condenser in relation to the condition of the condenser water. Any required corrective action shall be documented within the report.

Inspections; [_____].

[Six] [_____] copies of an inspection report, at the completion of one year of service, in bound 216 x 279 (81/2 x 11 inch) 8 1/2 x 11 inch booklets. The report shall identifying the condition of each cooling tower and condenser. The report shall also include a comparison of the condition of the cooling tower and condenser with the manufacturer's recommended operating conditions. The report shall identify all actions taken by the Contractor and manufacturer to correct deficiencies during the first year of service.

SD-07 Certificates

Central Refrigerated Air-Conditioning System; [_____].

Where the system, components, or equipment are specified to comply with requirements of AGA, NFPA, ARI, ASHRAE, ASME, or UL, [1] [_____] copy of proof of such compliance shall be provided. The label or listing of the specified agency shall be acceptable evidence. In lieu of the label or listing, a written certificate from an approved, nationally recognized testing organization equipped to perform such services, stating that the items have been tested and conform to the requirements and testing methods of the specified agency may be submitted. When performance requirements of this project's drawings and specifications vary from standard ARI rating conditions, computer printouts, catalog, or other application data certified by ARI or a nationally recognized laboratory as described above shall be included. If ARI does not have a current certification program that encompasses

such application data, the manufacturer may self certify that his application data complies with project performance requirements in accordance with the specified test standards.

Verification of Dimensions; [_____].

A letter, at least [2] [_____] weeks prior to beginning construction, including the date the site was visited, conformation of existing conditions, and any discrepancies found.

Manufacturer's Multi-Year Compressor Warranty; [_____]

Manufacturer's multi-year warranty for compressor(s) in air-cooled liquid chillers as specified.

Factory Tests; [_____].

[Six] [_____] copies of the report shall be provided in bound 216 x 279 mm (8 1/2 x 11 inch) 8 1/2 x 11 inch booklets. Reports shall certify the compliance with performance requirements and follow the format of the required testing standard for both the Chiller Performance Tests and the Chiller Sound Tests. Test report shall include certified calibration report of all test instrumentation. Calibration report shall include certification that all test instrumentation has been calibrated within 6 months prior to the test date, identification of all instrumentation, and certification that all instrumentation complies with requirements of the test standard. Test report shall be submitted [1] [_____] week after completion of the factory test.

SD-10 Operation and Maintenance Manuals

Operation Manual; [_____].

[Six] [_____] complete copies of an operation manual in bound 216 x 279 (81/2 x 11 inch) 8 1/2 x 11 inch booklets listing step-by-step procedures required for system startup, operation, abnormal shutdown, emergency shutdown, and normal shutdown at least [4] [_____] weeks prior to the first training course. The booklets shall include the manufacturer's name, model number, and parts list. The manuals shall include the manufacturer's name, model number, service manual, and a brief description of all equipment and their basic operating features.

Maintenance Manual; [_____].

[Six] [_____] complete copies of maintenance manual in bound 216 x 279 (81/2 x 11 inch) 8 1/2 x 11 inch booklets listing routine maintenance procedures, possible breakdowns and repairs, and a trouble shooting guide. The manuals shall include piping and equipment layouts and simplified wiring and control diagrams of the system as installed.

Water Treatment System; [_____].

[Six] [_____] complete copies of operating and maintenance manuals for the step-by-step water treatment procedures. The manuals shall include testing procedures used in determining water quality.

1.4 QUALIFICATIONS

****
NOTE: If the need exists for more stringent requirements for weldments, delete the first bracketed statement, otherwise delete the second.
****

[Piping shall be welded in accordance with the qualified procedures using performance qualified welders and welding operators. Procedures and welders shall be qualified in accordance with ASME BPV IX. Welding procedures qualified by others, and welders and welding operators qualified by another employer may be accepted as permitted by ASME B31.1. The Contracting Officer shall be notified 24 hours in advance of tests and the tests shall be performed at the work site if practical. The welder or welding operator shall apply his assigned symbol near each weld he makes as a permanent record. Structural members shall be welded in accordance with Section 05055 WELDING, STRUCTURAL.] [Welding and nondestructive testing procedures are specified in Section 05093 WELDING PRESSURE PIPING.]

1.5 SAFETY REQUIREMENTS

****
NOTE: Catwalk, ladder and guardrail may be required. If so, select the applicable item and delete the others and indicate on drawings the selected item. If not applicable, delete the entire sentence within the brackets.
****

Exposed moving parts, parts that produce high operating temperature, parts which may be electrically energized, and parts that may be a hazard to operating personnel shall be insulated, fully enclosed, guarded, or fitted with other types of safety devices. Safety devices shall be installed so that proper operation of equipment is not impaired. [[Catwalk,] [ladder,] [and guardrail] shall be provided where indicated and in accordance with Section 05500 MISCELLANEOUS METAL.]

1.6 DELIVERY, STORAGE, AND HANDLING

All equipment delivered and placed in storage shall be stored with protection from the weather, humidity and temperature variations, dirt and dust, or other contaminants.

1.7 PROJECT/SITE CONDITIONS

1.7.1 Verification of Dimensions

The Contractor shall become familiar with all details of the work, verify all dimensions in the field, and shall advise the Contracting Officer of any discrepancy before performing any work.

1.7.2 Drawings

Because of the small scale of the drawings, it is not possible to indicate all offsets, fittings, and accessories that may be required. The Contractor shall carefully investigate the plumbing, fire protection, electrical, structural and finish conditions that would affect the work to be performed and shall arrange such work accordingly, furnishing required offsets, fittings, and accessories to meet such conditions.

1.8 MANUFACTURER'S MULTI-YEAR COMPRESSOR WARRANTY

****

NOTE: This paragraph is to be used only in conjunction with an air-cooled liquid chiller. If an air-cooled liquid chiller is not specified, then delete this paragraph.

The designer will be responsible for selecting the length of the warrenty, the type (i.e., parts only, or parts and labor), and a response time. Coordinate the selections made with the installation and consider the needs and repair/response capabilities of the user, the criticality of the site, the location of the site in relation to the availability of manufacturer qualified technicians, and cost.

Response time is site/manufacturer dependent although for most sites a 6-hour response time is reasonable. Response time may differ from the response time indicated for items covered under the standard construction warranty. Designers must be aware that specifying a response time less than 24 hours for warranty service on chillers at remote sites may limit competition.

****

The Contractor shall provide a [5] [10] year [parts only (excludes refrigerant)][parts and labor (includes refrigerant)] manufacturer's warranty on the air-cooled chiller compressor(s). This warranty shall be directly from the chiller manufacturer to the Government and shall be in addition to the standard one-year warranty of construction. The manufacturer's warranty shall provide for the repair or replacement of the chiller compressor(s) that become inoperative as a result of defects in material or workmanship within [5] [10] years after the date of final acceptance. When the manufacturer determines that a compressor requires replacement, the manufacturer shall furnish new compressor(s) at no additional cost to the Government. Upon notification that a chiller compressor has failed under the terms of the warranty, the manufacturer

shall respond in no more than [6] [24] [_____] hours. Response shall mean having a manufacturer-qualified technician onsite to evaluate the extent of the needed repairs. The warranty period shall begin on the same date as final acceptance and shall continue for the full product warranty period.

1.8.1 Indexed Notebook

****

NOTE: Where multiple air-cooled liquid chillers are to be covered by a manufacturer's multi-year warranty, include the following paragraph. This paragraph requires a bound and indexed notebook.

****

The Contractor shall furnish to the Contracting Officer a bound and indexed notebook containing a complete listing of all air-cooled liquid chillers covered by a manufacturer's multi-year warranty. The chiller list shall state the duration of the warranty thereof, start date of the warranty, ending date of the warranty, location of the warrented equipment, and the point of contact for fulfillment of the warranty. Point of contact shall include the name of the service representative along with the day, night, weekend, and holiday phone numbers for a service call. The completed bound and indexed notebook shall be delivered to the Contracting Office prior to final acceptance of the facility.

1.8.2 Equipment Warranty Tags and Guarantor's Local Representative

The Contractor shall furnish with each manufacturer's multi-year warranty the name, address, and telephone number (day, night, weekend, and holiday) of the service representative nearest to the location where the equipment is installed. Upon a request for service under the multi-year warranty, the service representative shall honor the warranty during the warranty period, and shall provide the services prescribed by the terms of the warranty. At the time of installation, each item of manufacturer's multi-year warranted equipment shall be tagged with a durable, oil- and water-resistant tag, suitable for interior and exterior locations, resistant to solvents, abrasion, and fading due to sunlight. The tag shall be attached with copper wire or a permanent, pressure-sensitive, adhesive backing. The tag shall be installed in an easily noticed location attached to the warranted equipment. The tag for this equipment shall be similar to the following in format, and shall contain all of the listed information:

MANUFACTURER'S MULTI-YEAR WARRANTY EQUIPMENT TAG
Equipment/Product Covered: _____
Manufacturer:_____Model No.:_____Serial No.:__
Warranty Period: From _____to _____
Contract No.: _____
Warranty Contact: _____
Name: _____
Address: _____
Telephone: _____
STATION PERSONNEL SHALL PERFORM PREVENTIVE MAINTENANCE AND OPERATIONAL MAINTENANCE

PART 2 PRODUCTS

****

NOTE: Job specifications will be written to avoid restrictions on specific types of refrigerant (excluding CFC refrigerants) in order to encourage competitive bidding of available product offerings.

Minimum chiller efficiencies will either be presented in this specification or on the design drawings. Delete chiller efficiencies in the specification if efficiencies are shown on the drawings. If the efficiencies are shown on the drawings, reference the applicable ARI standard.

The following is a list of terms which are commonly used in regard to efficiency ratings of equipment defined within this specification.

COP - Coefficient of Performance (dimensionless)
EER - Energy Efficiency Ratio (Btuh/Watt)
IPLV - Integrated Part Load Value (dimensionless or kW/ton)
APLV - Application Part Load Value (dimensionless or kW/ton)

Note that the IPLV ratings presented by manufacturers are based upon standard rating conditions established by ARI. APLV ratings on the other hand are based upon site specific rating conditions. APLV ratings should be specified in most applications. APLV ratings will be coordinated with ARI and with the chiller manufacturers.

The following is a list of minimum full load and part load efficiency ratings to be used to specify electrically driven, air-cooled and water-cooled liquid chillers. Minimum efficiency ratings for absorption chillers are defined under paragraph ABSORPTION LIQUID CHILLER.

Minimum Efficiencies for Air-Cooled Chillers

	Full Load		IPLV	
	COP	(EER)	COP	(kW/ton)
Air-Cooled (with Condenser):				
527 kW (150 tons) or less =	**2.8**	**(9.5)**	**3.1**	**(1.12)**
greater than 527 kW (150 tons) =	**2.7**	**(9.2)**	**2.9**	**(1.22)**
Air-Cooled (Condenserless):				
All Capacities =	**3.1**	**(10.6)**	**3.2**	**(1.10)**

Minimum Efficiencies for Water-Cooled Chillers

Capacity	Full Load COP	Full Load (EER)	IPLV COP	IPLV (kW/ton)
281 kW (80 tons) or less =	3.9	(13.3)	4.7	(0.75)
greater than 281 kw (80 tons) or less than or equal to 351 kw (100 tons) =	3.9	(13.3)	5.1	(0.70)
greater than 351 kw (100 tons) or less than or equal to 702 kw (200 tons) =	4.7	(16.0)	5.4	(0.65)
greater than 702 kw (200 tons) or less than or equal to 1757 kw (500 tons) =	5.7	(19.4)	6.1	(0.58)
greater than 1757 kw (500 tons) =	5.9	(20.0)	6.3	(0.56)

Because of typical manufacturing practices, air-cooled and small water-cooled chillers (typically less than 527 kW (150 tons)) are not available in multiple efficiencies for each available capacity. Only one model, and therefore, only one efficiency is available from a manufacturer for a given capacity. The minimum efficiencies stated above for air-cooled and small water-cooled chillers are low enough to allow all of the major chiller manufacturers to competitively bid. Specifying a higher efficiency for air-cooled and small water-cooled chillers will limit competition and may require a sole source justification.

Larger water-cooled chillers (greater than 527 kW (150 tons) are available in multiple efficiencies for each available capacity. The minimum efficiencies stated above are only guidelines in specifying efficiencies. The designer will be responsible for developing a life cycle cost comparison between available efficiencies to determine the optimum alternative. The decision to specify a more efficiency liquid chiller than the minimums defined above will typically be driven by the kW-hour costs, the electrical demand costs, and the chiller's annual energy usage. A designer should develop a sole source justification (if applicable) to procure the most life cycle cost effective chiller applicable. Coordinate chiller efficiencies with chiller manufacturers prior

finalizing the specification.

The driving force in the procurement of higher efficient equipment is Executive Order 12902. Executive Order 12902 specifies that energy consuming products be selected which are in the top 25 percent of their class for energy efficiency or, at a minimum, at least 10 percent better than current federal minimum standards, to the extent practical and cost effective.

Full and part load efficiencies for gas-engine driven liquid chillers will have a COP of between 1.0 and 2.0 based upon operating conditions (i.e., with heat recovery, without heat recovery, etc.). A designer will coordinate with chiller manufacturers prior to specifying a minimum full or part load efficiency for a gas-engine driven chiller. Gas-engine driven chiller can be provided with compressors of the centrifugal type (typically larger than 2460 kW (700 tons)), the rotary screw type (intermediate sizes), the reciprocating type (typically up to 703 kW (200 tons)), and the scroll type (small system).

Projects which include vapor-compression type liquid chillers (this excludes absorption chillers) will comply with the safety standards defined in ASHRAE 15. Designers will be responsible for thoroughly researching and implementing the ASHRAE 15 safety requirements. For refrigerant-containing parts (excluding piping) located within an indoor space, a designer can use the following 6-step synopsis as a guide in determining "System Application Requirements" from ASHRAE 15.

Step 1. Identify the safety group classification of the refrigerant anticipated to be used in the new liquid chilling equipment. Refrigerants R-22 and R-134a are considered Group A1 refrigerants. Refrigerant R-123 is considered a Group B1 refrigerant.

Step 2. Identify the occupancy classification of the facility which will house the new liquid chilling equipment. Occupancies include institutional, public assembly, residential, commercial, large mercantile, industrial, and mixed types.

Step 3. Determine the system probability (high or low) of the new liquid chilling equipment. Liquid chillers are typically considered low-probability systems according to ASHRAE 15.

Step 4. Estimate the quantity of refrigerant (grams or pounds) in the largest single liquid chiller or largest refrigerant circuit of the new equipment. The designer will research catalog data from a minimum of 2 different liquid chiller manufacturers in order to get an approximation.

Step 5. Determine the volume (cubic meters or cubic feet) of the indoor space which is planned to house the new liquid chilling equipment.

Step 6. Identify the "System Application Requirements" from the applicable table in ASHRAE 15 based upon the information identified in the previous steps (e.g., safety group, occupancy, system probability, refrigerant quantity, and indoor space volume). The "System Application Requirements" will dictate applicable refrigerant limitations as well as occupied space or mechanical room requirements. Typically, indoor spaces housing liquid chilling equipment must meet the mechanical room requirements defined in ASHRAE 15.

ASHRAE 15 refers to a mechanical room as a machinery room, however, the terms are synonymous. On mechanical room design, ASHRAE 15 touches on criteria concerning chiller placement, ventilation design, door and passageway restrictions, refrigerant monitoring, open-flame devices, pressure-relief and purge piping. In addition to mechanical room design, ASHRAE 15 also touches on criteria concerning refrigerant piping, signs, self-contained breathing apparatus (SCBA), and miscellaneous installation restrictions. (SCBAs cannot be considered MCA funded items and are therefore not included in this specification.)

****

2.1 STANDARD COMMERCIAL PRODUCTS

Materials and equipment shall be standard products of a manufacturer regularly engaged in the manufacturing of such products, which are of a similar material, design and workmanship. The standard products shall have been in satisfactory commercial or industrial use for two years prior to bid opening. The two-year use shall include applications of equipment and materials under similar circumstances and of similar size. The two years experience shall be satisfactorily completed by a product which has been sold or is offered for sale on the commercial market through advertisements, manufacturer's catalogs, or brochures. Products having less than a two-year field service record shall be acceptable if a certified record of satisfactory field operation, for not less than 6000 hours exclusive of the manufacturer's factory tests, can be shown. All products shall be supported by a service organization. The Contractor

shall submit a certified list of qualified permanent service organizations for support of the equipment which includes their addresses and qualifications. These service organizations shall be reasonably convenient to the equipment installation and shall be able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

2.2 NAMEPLATES

Each major component of equipment shall have the manufacturer's name, address, type or style, and catalog or serial number on a plate securely attached to the item of equipment. As a minimum, nameplates shall be provided for:

a. Liquid-Chilling Package(s)
b. Compressor(s)
c. Compressor Driver(s)
d. Condenser(s)
e. Liquid Cooler(s)
f. Receiver(s)
g. Pump(s)
h. Pump Motor(s)
i. Cooling Tower(s)
j. Cooling Tower Gear Drive Assemblies
k. Refrigerant Leak Detectors
l. Expansion Tanks
m. Air Separator Tanks

2.3 ELECTRICAL WORK

****
NOTE: Where motor starters for mechanical equipment are provided in motor-control centers, the references to motor starters shall be deleted.
****

Electrical equipment, motors, motor starters, and wiring shall be in accordance with Section 16415 ELECTRICAL WORK, INTERIOR. Electrical motor driven equipment specified shall be provided complete with motors, motor starters, and controls. Electrical characteristics and enclosure type shall be as shown, and unless otherwise indicated, all motors of 745 W (1 horsepower) 1 horsepower and above with open, dripproof, or totally enclosed fan cooled enclosures, shall be high efficiency type. Field wiring shall be in accordance with manufacturer's instructions. Each motor shall conform to NEMA MG 1 and be of sufficient size to drive the equipment at the specified capacity without exceeding the nameplate rating of the motor. Motors shall be continuous duty with the enclosure specified. Motor starters shall be provided complete with thermal overload protection and other appurtenances necessary for the motor control indicated. Motors shall be furnished with a magnetic across-the-line or reduced voltage type starter as required by the manufacturer. Motor starter shall be provided in enclosures constructed in accordance with UL and [NEMA 1] [NEMA 3R] [NEMA [_____]] enclosures. Manual or automatic control and protective or signal devices required for the operation specified and any control wiring

required for controls and devices specified, but not shown, shall be provided.

2.4 SELF-CONTAINED LIQUID CHILLER

****
NOTE: Typically, units 500 tons or smaller are fully assembled and run-tested at the factory. Units larger than 500 tons are typically shipped and then assembled, charged, and run-tested in the field.
****

Unless necessary for delivery purposes, units shall be assembled, leak-tested, charged (refrigerant and oil), and adjusted at the factory. In lieu of delivery constraints, a chiller may be assembled, leak-tested, charged (refrigerant and oil), and adjusted at the job site by a factory representative. Unit components delivered separately shall be sealed and charged with a nitrogen holding charge. Unit assembly shall be completed in strict accordance with manufacturer's recommendations. Chiller shall operate within capacity range and speed recommended by the manufacturer. Parts weighing 23 kg 50 pounds or more which must be removed for inspection, cleaning, or repair, such as motors, gear boxes, cylinder heads, casing tops, condenser, and cooler heads, shall have lifting eyes or lugs. Chiller shall be provided with factory installed insulation on surfaces subject to sweating including the liquid cooler, suction line piping, economizer, and cooling lines. Chiller shall include all customary auxiliaries deemed necessary by the manufacturer for safe, controlled, automatic operation of the equipment. Chiller shall be provided with a single point wiring connection for incoming power supply. Factory installed insulation shall be provided on all suction piping from the evaporator to the compressor and on the liquid cooler shell. Where motors are the gas-cooled type, factory installed insulation shall be provided on the cold-gas inlet connection to the motor per manufacturer's standard practice. Chiller's condenser and liquid cooler shall be provided with [standard] [marine] water boxes with [grooved mechanical] [flanged] [welded] connections.

2.4.1 Scroll, Reciprocating, or Rotary Screw Type

****
NOTE: These type units are typically available in capacities of 1406 kW (400 tons) or less.
****

Chiller shall be constructed and rated in accordance with ARI 590. Chiller shall be conform to ASHRAE 15. [Chiller shall have a minimum full load COP EER rating of [_____] and a part load COP kW/ton rating of [_____] in accordance with ARI 590.] As a minimum, chiller shall include the following components as defined in paragraph CHILLER COMPONENTS.

a. Refrigerant and oil
b. Structural base
c. Controls package
d. Scroll, reciprocating, or rotary screw compressor

e. Compressor driver, [electric motor] [gas-engine]
f. Compressor driver connection
g. Liquid cooler (evaporator)
f. [Air-] [Water-] condenser coil
g. [Heat recovery condenser]
h. [Receiver]
i. Tools
j. Chiller refrigerant circuit

****

Edit the applicable manufacturer references and model references into the clauses as shown below. These products listed below represent the recommended manufacturer's products by the Army Reserve. Designers shall use professional judgement and up-to-date manufacturer information while editing and revising this list.

****

2.4.1.1 Acceptable Manufacturers of Self-Contained Liquid scroll, Reciprocating, or Rotary Screw Type Chillers

Carrier Corp., Model [_____].
Dunham-Bush, Inc., Model [_____].
Snyder General Corp., Model [_____].
Trane Company, Model [_____].
York International Corp., Model [_____].
Or an approved equal in accordance with section 00700, Materials and Workmanship.

2.4.2 Centrifugal or Rotary Screw Type

****

NOTE: These type units are typically available in capacities of 703 kW (150 tons) or more.

Rotary screw type units can be rated in accordance with either ARI 550 or ARI 590. The primary difference between the two deals with the method of unloading. ARI 550 provides for continuous, non-stepped unloading from full load, down to minimum load. ARI 590, on the other hand, provides for stepped unloading in discrete increments between full load and part load (e.g., 100, 75, 50, 25, off) similar to reciprocating compressors. Typically, water-cooled rotary screw chillers larger than 200 tons are based upon ARI ANSI/ARI 550, while the smaller water-cooled and air-cooled models are based upon ARI 590.

****

Centrifugal chiller shall be constructed and rated in accordance with ARI 550. Rotary screw chiller shall be constructed and rated in accordance with ARI 550 or ARI 590 as applicable. [Chiller shall have a minimum full load COP EER rating of [_____] and a part load COP kW/ton rating of [_____]

in accordance with ARI 550 or ARI 590 as applicable.] Chiller shall conform to ASHRAE 15. As a minimum, chiller shall include the following components as defined in paragraph CHILLER COMPONENTS.

a. Refrigerant and oil
b. Structural base
c. Controls package
d. Centrifugal or rotary screw compressor
e. Compressor driver, [electric motor] [gas-engine] [steam turbine]
f. Compressor driver connection
g. Liquid cooler (evaporator)
h. [Air-] [Water-] cooled condenser coil
i. [Heat recovery condenser coil]
i. [Receiver]
j. Purge system for chillers which operate below atmospheric pressure
k. Tools

2.4.2.1 Acceptable Manufacturers Of Self-Contained Liquid, Centrifugal Or Rotary Screw Type Chillers.

Carrier Corp., Model [_____].
Snyder General Corp., Model [_____].
Trane Company, Model [_____].
York International Corp., Model [_____].
Or an approved equal in accordance with section 00700, Materials and Workmanship.

2.5 SPLIT-SYSTEM LIQUID CHILLER

Total chiller system shall be constructed and rated in accordance with ARI 590. Individual chiller components shall be constructed and rated in accordance with the applicable ARI standards. Chiller system shall be conform to ASHRAE 15. [Chiller shall have a minimum full load COP EER rating of [_____] and a part load COP kW/ton rating of [_____] in accordance with ARI 590.] Chiller shall be assembled, leak-tested, charged (refrigerant and oil), and adjusted at the job site by a factory representative. Unit components delivered separately shall be sealed and charged with a nitrogen holding charge. Unit assembly shall be completed in strict accordance with manufacturer's recommendations. Chiller shall operate within capacity range and speed recommended by the manufacturer. Parts weighing 23 kg 50 pounds or more which must be removed for inspection, cleaning, or repair, shall have lifting eyes or lugs. Chiller components (excluding field installed refrigerant piping) shall be provided with factory installed insulation on surfaces subject to sweating. Chiller shall include all customary auxiliaries deemed necessary by the manufacturer for safe, controlled, automatic operation of the equipment. Chiller's condenser and liquid cooler shall be provided with [standard] [marine] water boxes with [grooved mechanical] [flanged] [welded] connections. As a minimum, chiller shall include the following components as defined in paragraph CHILLER COMPONENTS.

a. Refrigerant and oil
b. Structural base
c. Controls package

d. [Receiver]
e. Tools
f. Chiller refrigerant circuit

2.5.1 Compressor-Chiller

****
NOTE: For a complete system, a compressor-chiller must be specified along with a remote condenser.
****

As a minimum, the compressor-chiller unit shall include the following components as defined in paragraph CHILLER COMPONENTS.

a. Scroll, reciprocating, or rotary screw compressor
b. Compressor driver, electric motor
c. Compressor driver connection
d. Liquid cooler (evaporator)

2.5.1.1 Acceptable Manufacturers of Split-System Liquid Compressor-Chiller

Carrier Corp., Model [_____].
Snyder General Corp., Model [_____].
Trane Company, Model [_____].
York International Corp., Model [_____].
Or an approved equal in accordance with section 00700, Materials and Workmanship.

2.5.2 Remote Air-Cooled Condenser

Condenser shall be a factory-fabricated and assembled unit, consisting of coils, fans, and electric-motor drive. Condenser shall be constructed and rated in accordance with ARI 460. Unless the condenser coil is completely protected through inherent design, louvered panel coil guards shall be provided by the manufacturer to prevent physical damage to the coil. Manufacturer shall certify that the condenser and associated equipment are designed for the submitted condensing temperature. For design conditions, if matched combination catalog ratings matching remote condensers to compressors are not available, the Contractor shall furnish a crossplotting of the gross heat rejection of the condenser against the gross heat rejection of the compressor, for the design conditions to show the compatibility of the equipment furnished.

2.5.2.1 Condenser Casing

Condenser casing shall be aluminum not less than 2 mm (0.080 inch) 0.080 inch or hot-dip galvanized steel not lighter than 1.2 mm (18 gauge).18 gauge. Condensers having horizontal air discharge shall be provided with discharge baffle to direct air upward, constructed of the same material and thickness as the casing.

2.5.2.2 Coil

****

NOTE: Standard coil construction is copper tubes with aluminum fins. For excessively corrosive atmospheres, either copper tubes with copper fins or aluminum tubes with aluminum fins should be considered. For additional corrosion protection, specify the manufacturer's standard epoxy or vinyl coating.

****

Condenser coil shall be of the extended-surface fin-and-tube type and shall be constructed of seamless [copper] [or] [aluminum] tubes with compatible [copper] [or] [aluminum] fins. Fins shall be soldered or mechanically bonded to the tubes and installed in a metal casing. Coils shall be circuited and sized for a minimum of 3 degrees C 5 degrees F subcooling and full pumpdown capacity. Coil shall be factory leak and pressure tested after assembly in accordance with ASHRAE 15. [Coil shall be entirely coated with the manufacturer's standard epoxy or vinyl coating.]

2.5.2.3 Fans

****

NOTE: When the density of the ambient air to be handled by the fans differs substantially from the density of the standard air value of 1.2 kg per cubic m (0.075 pound per cubic foot) at 21 degrees C (70 degrees F) and 101 kPa (29.92 inches mercury), the density of the air and/or the elevation above mean sea level will be stated.

****

Fans shall be centrifugal or propeller type as best suited for the application. Fans shall be direct or V-belt driven. Belt drives shall be completely enclosed within the unit casing or equipped with a guard. When belt drive is provided, an adjustable sheave to furnish not less than 20 percent fan-speed adjustment shall be provided. Sheaves shall be selected to provide the capacity indicated at the approximate midpoint of the adjustment. Fans shall be statically and dynamically balanced.

2.5.2.4 Acceptable Manufacturers of Remote Air-Cooled Condenser

Carrier Corp., Model [_____].
Snyder General Corp., Model [_____].
Trane Company, Model [_____].
York International Corp., Model [_____].
Or an approved equal in accordance with section 00700, Materials and Workmanship.

2.5.3 Remote Water-Cooled Condenser

Condenser shall be a factory-fabricated and assembled unit constructed and rated in accordance with ARI 450. Condenser shall be of the shell-and-coil or shell-and-tube type design. Condenser's refrigerant side shall be designed and factory pressure tested to comply with ASHRAE 15. Condenser's water side shall be designed and factory pressure tested for not less than [

1,000 kPa 150 psi] [1,700 kPa 250 psi]. Condensers shall be complete with pressure relief valve or rupture disk, water drain connections, refrigerant charging valve, and stand or saddle. Low pressure refrigerant condenser shall be provided with a purge valve located at the highest point in the condenser to purge non-condensibles trapped in the condenser. Condenser shell shall be constructed of seamless or welded steel. Coil bundles shall be totally removable and arranged to drain completely. Tubes shall be seamless copper, plain, integrally finned with smooth bore or integrally finned with enhanced bore. Each tube shall be individually replaceable, except for the coaxial tubes. Tubes shall be installed into carbon mild steel tube sheets by rolling. Tube baffles shall be properly spaced to provide adequate tube support and cross flow.

2.5.3.1 Performance

Performance shall be based on water velocities not less than 0.91 m/s (3 fps) 3 fps nor more than 3.7 mm (12 fps) 12 fps and a fouling factor of [0.00025] [0.0005].

2.5.3.2 Refrigerant Storage

Water-cooled condensers may be used for refrigerant storage in lieu of a separate liquid receiver, if the condenser storage capacity is 5 percent in excess of the fully charged system for single packaged systems and 20 percent in excess of the fully charged system for remote water cooled condensers.

2.5.4 Remote Evaporatively-Cooled Condenser

Condenser shall be rated and tested in accordance with requirements of ASHRAE 64. Condenser shall include fans, water pump with suction strainer, electric motor and drive equipment, water eliminators if required, condensing coil, liquid receiver if required, water pan or sump, spray nozzles or water-distribution pan, water strainer, water make-up assembly, bleeder with flow valve of the needle valve type sized for the flow required or a fixed orifice, enclosure with suitable access doors, and air-inlet and outlet openings. No water shall carry over into the unit discharge outlet.

2.5.4.1 Condenser Casing

Enclosure shall be constructed of not lighter than [1.3 mm 18 gauge hot-dip galvanized steel] [2.0 mm 0.080 inch aluminum], reinforced and braced. Access doors or panels suitably sized and located shall be provided for access to water nozzles or distribution pan, coils, and valves for cleaning, repair, or removal of the item. Access doors or panels shall be gasketed with synthetic rubber, or equivalent gasket material, and locked in place with thumb screws or catches. One-half inch mesh hot-dip galvanized steel or copper air-inlet screens shall be provided on each air inlet.

2.5.4.2 Refrigerant Section

Condenser coil shall be constructed of unfinned copper or steel tubes

hot-dip galvanized after fabrication. The receiver shall be welded steel and shall be fitted and tested in accordance with ARI 495. A refrigerant charging valve shall be installed in the liquid line between the receiver cut-off valve and the expansion device. Refrigerant section shall be tested in accordance with ASHRAE 15 for the refrigerant employed in the system.

2.5.4.3 Fans

****

NOTE: When the density of the ambient air to be handled by the fans differs substantially from the density of the standard air value of 1.2 kg per cubic m (0.075 pound per cubic foot) at 21 degrees C (70 degrees F) and 101 kPa (29.92 inches mercury), the density of the air and/or the elevation above mean sea level will be stated.

****

Fans shall be centrifugal or propeller type as best suited for the application. Fans shall be direct or V-belt driven. Belt drives shall be completely enclosed within the unit casing or equipped with a guard. When belt drive is provided, an adjustable sheave to furnish not less than 20 percent fan-speed adjustment shall be provided. Sheaves shall be selected to provide the capacity indicated at the approximate midpoint of the adjustment. Fans shall be statically and dynamically balanced. Fan motor shall be totally enclosed type or open dripproof and located within an enclosure to be fully protected from the weather.

2.5.4.4 Water Section

Water eliminators shall be constructed of nonferrous metal, of an approved nonmetallic material, or of not lighter than 0.6 mm (24 gauge) 24 gauge steel, hot-dip galvanized after fabrication. Spray nozzles shall be brass nonclogging type designed to permit easy disassembly, and shall be arranged for easy access. Water pump shall be bronze-fitted centrifugal or turbine type, and may be mounted as an integral part of the evaporative condenser or remotely on a separate mounting pad. Pump suction shall be fully submerged and provided with screened inlet. Water pan or sump shall be constructed of not lighter than 1.8 mm (14 gauge) 14 gauge steel, hot-dip galvanized after fabrication, or molded acid-resistant glass-fiber-reinforced polyester. Water distribution pan shall be constructed of not lighter than 1.6 mm 16 gauge steel, hot-dip galvanized after fabrication. Joints shall be watertight. Water pan or sump shall be provided with drain, overflow, and make-up water connection with stop valve and float valve. A bleed line with a flow valve of the needle type sized for the flow required or fixed orifice shall be provided in the pump discharge line and shall be extended to the nearest drain for continuous discharge.

2.5.5 Compressor Unit

****

NOTE: For a complete system, a compressor unit must

be specified along with a remote condenser and a remote liquid cooler.

****

As a minimum, the condensing unit shall include the following components as defined in paragraph CHILLER COMPONENTS.

a. Scroll, reciprocating, or rotary screw compressor
b. Compressor driver, electric motor
c. Compressor driver connection

2.5.6 Remote Liquid Cooler (Evaporator)

Condenser shall be constructed and rated in accordance with ARI 480. Cooler shall be of the shell-and-coil or shell-and-tube type design. Condenser's refrigerant side shall be designed and factory pressure tested to comply with ASHRAE 15. Condenser's water side shall be designed and factory pressure tested for not less than [1,000 kPa 150 psi] [1,700 kPa 250 psi]. Cooler shell shall be constructed of seamless or welded steel. Coil bundles shall be totally removable and arranged to drain completely. Tubes shall be seamless copper, plain, integrally finned with smooth bore or integrally finned with enhanced bore. Each tube shall be individually replaceable. Tubes shall be installed into carbon mild steel tube sheets by rolling. Tube baffles shall be properly spaced to provide adequate tube support and cross flow. Cooler shall be skid-mounted. Refrigerant circuit shall be complete with liquid solenoid valve and expansion device capable of modulating to the minimum step of capacity unloading.

2.6 CHILLER COMPONENTS

****

NOTE: Coordinate the type of chiller components required with the type of chiller specified in the previous paragraphs. Components define under this paragraph do not apply to absorption type chillers. Delete this paragraph if only absorption type chillers are specified.

****

2.6.1 Refrigerant and Oil

****

NOTE: Non-absorption type chillers shall operate on a refrigerant with an ozone depletion potential (ODP) less than or equal to 0.05. R-22, R-123 and R-134a all meet this requirement.

****

Refrigerants shall be one of the fluorocarbon gases. Refrigerants shall have number designations and safety classifications in accordance with ASHRAE 34. Refrigerants shall meet the requirements of ARI 700 as a minimum. Refrigerants shall have an Ozone Depletion Potential (ODP) of less than or equal to 0.05.

2.6.2 Structural Base

Chiller and individual chiller components shall be provided with a factory-mounted welded structural steel base or support legs. Chiller and individual chiller components shall be isolated from the building structure by means of [molded neoprene isolation pads.] [vibration isolators with published load ratings. Vibration isolators shall have isolation characteristics as recommended by the manufacturer for the unit supplied and the service intended.]

2.6.3 Chiller Refrigerant Circuit

Chiller refrigerant circuit shall be completely piped and factory leak tested. For multicompressor units, not less than 2 independent refrigerant circuits shall be provided. Circuit shall include as a minimum a combination filter and drier, combination sight glass and moisture indicator, liquid-line solenoid valve for reciprocating or scroll units, an electronic or thermostatic expansion valve with external equalizer, charging ports, compressor service valves, and superheat adjustment.

2.6.4 Controls Package

Chiller shall be provided with a complete factory mounted and prewired electric or microprocessor based control system. Controls package shall be [unit-mounted] [floor-mounted where indicated] which contains as a minimum a digital display or acceptable gauges, an on-auto-off switch, motor starters, power wiring, control wiring, and disconnect switches. Controls package shall provide operating controls, monitoring capabilities, programmable setpoints, safety controls, and EMCS interfaces as defined below.

2.6.4.1 Operating Controls

****

NOTE: For proper startup and head pressure controls, enter the winter design temperature that the equipment will be subjected. Coordinate this temperature with manufacturers to assure available equipment.

A cooling tower bypass line and modulating control valve should be evaluated and incorporated into a design which requires chiller operation in ambient temperatures less than 13 degrees C (55 degree F).

****

Chiller shall be provided with the following adjustable operating controls as a minimum.

a. Leaving chilled water temperature control

b. Adjustable timer to prevent compressor from short cycling

c. Automatic lead/lag controls (adjustable) for multiprocessor units

d. Load limiting

e. [Fan sequencing for air-cooled condenser]

f. System capacity control to adjust the unit capacity in accordance with the system load and the programmable setpoints. Controls shall automatically re-cycle the chiller on power interruption.

g. Startup and head pressure controls to allow system operation at all ambient temperatures down to [_____] degrees [C][F]

2.6.4.2 Monitoring Capabilities

During normal operations, the control system shall be capable of monitoring and displaying the following operating parameters. Access and operation of display shall not require opening or removing any panels or doors.

a. Entering and leaving chilled water temperatures
b. Self diagnostic
c. Operation status
d. Operating hours
e. Number of starts
f. Compressor status (on or off)
g. Refrigerant discharge and suction pressures
h. [Condenser water entering and leaving temperatures]
i. [Number of purge cycles over the last 7 days]

2.6.4.3 Programmable Setpoints

The control system shall be capable of being reprogrammed directly at the unit. No parameters shall be capable of being changed without first entering a security access code. The programmable setpoints shall include the following as a minimum.

a. Leaving Chilled Water Temperature
b. [Leaving Condenser Water Temperature]
c. Time Clock/Calender Date

2.6.4.4 Safety Controls with Manual Reset

Chiller shall be provided with the following safety controls which automatically shutdown the chiller and which require manual reset.

a. Low chilled water temperature protection
b. High condenser refrigerant discharge pressure protection
c. Low suction pressure protection
d. Chilled water flow detection
e. Motor current overload and phase loss protection
f. High motor winding temperature protection for hermetic motors
g. Low oil flow protection

2.6.4.5 Safety Controls with Automatic Reset

Chiller shall be provided with the following safety controls which automatically shutdown the chiller and which provide automatic reset.

a. Over/under voltage protection
b. Phase reversal protection
c. Chilled water flow interlock

2.6.4.6 Remote Alarm

During the initiation of a safety shutdown, the control system shall be capable of activating a remote alarm bell. In coordination with the chiller, the contractor shall provide an alarm circuit (including transformer if applicable) and a minimum 100 mm (4 inch) 4 inch diameter alarm bell. Alarm circuit shall activate bell in the event of machine shutdown due to the chiller's monitoring of safety controls. The alarm bell shall not sound for a chiller that uses low-pressure cutout as an operating control.

2.6.4.7 Energy Management Control System (EMCS) Interface

The control system shall be capable of communicating all data to a remote integrated DDC processor through a single shielded cable. The data shall include as a minimum all system operating conditions, capacity controls, and safety shutdown conditions. The control system shall also be capable of receiving at a minimum the following operating commands.

a. Remote Unit Start/Stop
b. Remote Chilled Water Reset
c. Remote Condenser Water Reset

2.6.5 Compressor(s)

2.6.5.1 Reciprocating Compressor(s)

All rotating parts shall be statically and dynamically balanced at the factory to minimize vibration. Compressors shall be capable of operating at partial-load conditions without increased vibration over the normal vibration at full load operation and shall be capable of continuous operation down to the lowest step of unloading as specified. Compressors of size 7.45 kW (10 horsepower) 10 horsepower and above shall have an oil lubrication system of the reversible, forced-feed type with oil strainer. Shaft seal in open-type units shall be mechanical type. Piston speed for open-type compressors shall not exceed the manufacturer's recommendation or 6 m/s (1200 fpm), 1200 fpm, whichever is less. Compressors shall include:

a. Vertical, V, W, or radial cylinder design

b. Oil lubrication

c. Integrally cast block of close-grained iron or cast aluminum block with hardened steel cylinder sleeves

d. Oil-level bull's eye

e. Cast cylinder heads

f. Cast-aluminum or forged-steel connecting rods

g. Cast iron or forged-steel crankshaft

h. Main bearings of the sleeve-insert type

i. Crankcase oil heaters controlled as recommended by the manufacturer

j. Suction and discharge refrigerant service valves that are flange connected, wrench operated, with cap

k. A strainer on the suction side of the compressor

l. [A hot-gas muffler to reduce vibration and noise from pulsations]

2.6.5.2 Scroll Compressor(s)

Compressors shall be of the compliant, hermetically sealed design. Compressors shall be mounted on vibration isolators to minimize vibration and noise. Rotating parts shall be statically and dynamically balanced at the factory to minimize vibration. Lubrication system shall be centrifugal pump type equipped with a means for determining oil level and an oil charging valve. Crankcase oil heater shall be provided if standard or if available as an option. If provided, the crankcase oil heater shall be controlled as recommended by the manufacturer.

2.6.5.3 Rotary Screw Compressor(s)

Compressors shall operate stably for indefinite time periods at any stage of capacity reduction without hot-gas bypass. Provision shall be made to insure proper lubrication of bearings and shaft seals on shutdown with or without electric power supply. Rotary screw compressors shall include:

a. An open or hermetic, positive displacement, oil-injected design directly driven by the compressor driver. Compressor shall allow access to internal compressor components for repairs, inspection, and replacement of parts.

b. Rotors which are solid steel forging with sufficient rigidity for proper operation.

c. A maximum rotor operating speed no greater than 3600 RPM.

d. Casings of cast iron, precision machined for minimal clearance about periphery of rotors.

e. A lubrication system of the forced-feed type that provides oil at the proper pressure to all parts requiring lubrication.

f. Shaft main bearings of the sleeve type with heavy duty bushings or rolling element type in accordance with AFBMA Std 9 or AFBMA Std 11. Bearings shall be conservatively loaded and rated for an L(10)

life of not less than 200,000 hours.

g. A differential oil pressure or flow cutout to allow the compressor to operate only when the required oil pressure or flow is provided to the bearings.

h. A temperature- or pressure-initiated, hydraulically actuated, single-slide-valve, capacity-control system to provide minimum automatic capacity modulation from 100 percent to 25 percent.

i. An oil separator and oil return system to remove oil entrained in the refrigerant gas and automatically return the oil to the compressor.

j. Crankcase oil heaters controlled as recommended by the manufacturer.

2.6.5.4 Centrifugal Compressor(s)

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NOTE: When centrifugal chillers are used for heat recovery duty, the entering heat recovery condenser water temperature is usually controlled to between 35 and 40 degrees C (95 and 105 degrees F) so that the water temperature leaving the heat recovery condenser is high enough to be used as a heat source. Under these conditions, the chiller will be operating at a higher head pressure than normally encountered. At these high head conditions, the centrifugal compressor may surge at part-load conditions of as high as 30 percent to 40 percent depending upon the conditions to which the chiller is subjected. In these cases, the designer should survey the manufacturers to determine at what load the available chillers will surge, at the conditions and loads to be encountered at the site. The bracketed sentences will be removed from the centrifugal chiller paragraph and replaced with the appropriate capacity control requirements. The designer should also consider multiple chillers to satisfy the load and to partition the loading to the chillers such that the heat recovery chiller load is sufficiently high to avoid surge. When examining heat recovery, full consideration should be given to the effect of 35-40 degrees C (95-105 degree F) water and the resulting power requirements of the chiller on the economic benefit of heat recovery.

****

Centrifugal compressors shall be single or multistage, having dynamically balanced impellers, either direct or gear driven by the compressor driver. Impellers shall be over-speed tested at 1.2 times the impeller-shaft speed. Impeller shaft shall be heat-treated alloy steel with sufficient rigidity for proper operation at any required operating speed. Centrifugal

compressors shall include:

a. Shaft main bearings that are the rolling element type in accordance with AFBMA Std 9 or AFBMA Std 11, journal type with bronze or babbitt liners, or of the aluminum-alloy one-piece insert type. Bearings shall be rated for an L(10) life of not less than 200,000 hours.

b. Casing of cast iron, aluminum, or steel plate with split sections gasketed and bolted or clamped together.

c. Lubrication system of the forced-feed type that provides oil at the proper pressure to all parts requiring lubrication.

d. Provisions to ensure proper lubrication of bearings and shaft seals prior to starting and upon stopping with or without electric power supply. On units providing forced-feed lubrication prior to starting, a differential oil pressure cutout interlocked with the compressor starting equipment shall allow the compressor to operate only when the required oil pressure is provided to the bearings.

e. Oil sump heaters controlled as recommended by the manufacturer.

f. Temperature-or pressure-actuated prerotation vane or suction damper to provide automatic capacity modulation from 100 percent capacity to 10 percent capacity. If operation to 10 percent capacity cannot be achieved without providing hot-gas bypass, then the Contractor shall indicate in the equipment submittal the load percent at which hot gas bypass is required.

2.6.6 Compressor Driver, Electric Motor

Motor shall be the polyphase, induction type conforming to NEMA MG 1. Motors shall be suitable for use with the indicated electrical power characteristics and the type of starter provided. Motor starters shall be the reduced voltage, closed-transition type conforming to NEMA ICS 1 and NEMA ICS 2. Motor starter shall be [unit mounted] [remote mounted] as indicated with starter type, wiring, and accessories coordinated by the chiller manufacturer. Starter shall be able to operate in temperatures up to 120 degrees F.

2.6.7 Compressor Driver, Gas-Engine

****

NOTE: Natural gas-engine drives are used in conjunction with either reciprocating, rotary, or centrifugal type compressors.

The decision to use a heavy duty industrial type engine as compared to a standard automotive type engine will be based strictly on an economic comparison. The standard automotive type engines have a much lower initial cost, but they must be

replaced and/or overhauled much more often. Also note that typically, standard automotive type engines are only available for chillers with a capacity of 500 tons or less.

****

Gas-engine compressor driver shall operate on natural gas and be in accordance with NFPA 37 and NFPA 54. Engine shall be designed for stationary applications and include all ancillaries necessary for operation. Engine shall be a manufacturer's standard production model and be specifically designed for chiller operation. Engine shall include as a minimum a [heavy duty industrial] [standard automotive] grade block, starting system, lubrication system, coolant system, engine heat exchanger, [engine cooling radiator,] fuel supply system, and controls package. Engine shall be naturally aspired, supercharged, or turbocharged and include appropriate air filters. Engine shall be 2- or 4-stroke-cycle and compression-ignition type. Engine shall be vertical in-line, V- or opposed-piston type, with a solid cast block or individually cast cylinders. Engine shall have a minimum of 2 cylinders. Opposed-piston type engines shall have not less than 4 cylinders. Engine block shall have a coolant drain port.

2.6.7.1 Starting System

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NOTE: Specify either an electric or pneumatic type starting system. Electric type system will be used for most applications. For installations where a compressed air system exists or is to be installed, a pneumatic starting system should be considered.

****

Engine starting system shall be the [electric] [pneumatic] type and be of sufficient capacity, at the maximum temperature specified, to crank the engine without damage or overheating. [Electric starting system shall operate on a [24] [_____]-volt DC system utilizing a negative circuit ground. A starting battery system shall be provided and shall include the battery, corrosion resistant battery rack, intercell connectors, spacers, automatic engine driven battery charger with overcurrent protection, metering and relaying. Battery shall be in accordance with SAE J 537. Battery charger shall conforming to UL 1236 and be the current-limiting type with overcurrent protection.] [Pneumatic starting system shall be as specified in Section 15400 PLUMBING, GENERAL PURPOSE, for a working pressure of [1.03 MPa (150 psi) 150 psi]].

2.6.7.2 Lubrication System

Engine shall be provided with a pressurized oil lubrication system. System shall include a lubrication oil pump that is engine driven. One full-flow filter shall be provided for each pump. Filters shall be readily accessible and capable of being changed without disconnecting the piping or disturbing other components. System pressure shall be regulated as recommended by the engine manufacturer. A pressure relief valve shall be provided on the crankcase. Crankcase breathers shall be piped to the

outside. System shall be readily accessible for servicing such as draining, refilling, and overhauling.

2.6.7.3 Coolant System

Engine shall include an automatic engine jacket water cooling system. Water shall be circulated through the system with an engine-driven circulating pump. [System coolant shall use a combination water and ethylene-glycol sufficient for freeze protection at the minimum temperature specified.]

2.6.7.4 Engine Heat Exchanger

Engine heat exchanger shall be of the shell-and-tube type construction and be in accordance with ASME BPV VIII Div 1. Shell material shall be carbon steel. Tubes shall be seamless copper or copper-nickel. Tubes shall be individually replaceable. Unit's waterside working pressure shall be rated for not less than 1,000 kPA (150 psig) 150 psig and factory tested at 150 percent of design working pressure. Water connections larger than 75 mm (3 inches) 3 inches shall be ASME Class 1500 flanged. Unit shall be provided with gasketed removable covers, drains, and vents.

2.6.7.5 Engine Cooling Radiator

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NOTE: An engine cooling radiator will be needed to satisfy an engine's cooling requirements if cooling tower water or heat recovery is not used.

****

Heat exchanger may be factory coated with corrosive resistant film, provided that correction measures are taken to restore the heat rejection capability of the radiator to the initial design requirement via over sizing, or other compensating methods. Internal surfaces shall be compatible with liquid fluid coolant used. Materials and coolant are subject to approval by the Contracting Officer. Heat exchangers shall be the pressure type incorporating a pressure valve, vacuum valve and a cap. Caps shall be designed for pressure relief prior to removal. Each heat exchanger and the entire cooling system shall be capable of withstanding a minimum pressure of 48 kPa (7 psi) 7 psi and shall be protected with a strong grille or screen guard. Each heat exchanger shall have at least 2 tapped holes; one shall be equipped with a drain cock, the rest shall be plugged.

2.6.7.6 Fuel Supply System

Engine fuel supply system shall be factory mounted. System shall include a solenoid shut-off valve, a gas pressure regulator, carburetors or fuel injectors, and a throttle body assembly.

2.6.7.7 Controls Package

The controls for the gas-engine shall be incorporated into the overall controls package for the liquid chiller. The engine controls shall be capable of monitoring, displaying, and controlling the following conditions.

a. Coolant-fluid inlet and outlet temperatures
b. Lubricating-oil inlet and outlet temperatures and pressures
c. Engine run-time hours
d. Engine current status mode (on/off)
e. Engine speed
f. Percent engine load
g. Engine jacket temperature

2.6.7.8 Exhaust Piping

Horizontal sections of exhaust piping shall be sloped downward away from the engine to a drip leg for collection of condensate with drain valve and cap. Changes in direction shall be long radius. Exhaust piping and mufflers shall be insulated in accordance with Section 15080 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Vertical exhaust piping shall be provided with a hinged, gravity-operated, self-closing, rain cover.

2.6.7.9 Exhaust Muffler

Engine shall be provided with a chamber type exhaust muffler. The muffler shall be of welded steel and designed for [outside] [inside] [vertical] [horizontal] mounting. Eyebolts, lugs, flanges, or other items shall be provided as necessary for support in the location and position indicated. Pressure drop through the muffler shall not exceed the recommendations of the engine manufacturer. Outside mufflers shall be zinc coated or painted with high temperature [_____] degrees resisting paint. The muffler and exhaust piping together shall reduce the noise level to less than [_____] dBa at a distance of 22.9 m (75 feet) 75 feet from the end of the exhaust piping with the chiller operating at 100 percent of rated output capacity. The muffler shall have a drain valve, nipple, and cap at the low-point of the muffler.

2.6.7.10 Exhaust System Connections

Flexible connectors shall be provided at the exhaust piping connection to the engine. An expansion joint shall be provided in the exhaust piping at the muffler connection. Flexible connectors and expansion joints shall have flanged connections. Flexible sections shall be made of convoluted seamless tube without joints or packing. Expansion joints shall be the bellows type. Expansion and flexible elements shall be stainless steel suitable for engine exhaust gas at 538 degrees C (1000 degrees F).1000 degrees F. Flexible connectors and expansion joints shall be capable of absorbing vibration from the engine and compensation for thermal expansion and contraction.

2.6.8 Compressor Driver, Steam Turbine

Steam turbine shall conform to NEMA SM 23 and be suitable for direct connection to the compressor. Turbine shall have a capacity 10 percent greater than the compressor brake horsepower requirement at full-load condition. Steam strainer shall be either internally mounted or installed in connecting piping. Turbine shall include sentinel warning valve, forced-feed lubrication, oil cooler, oil reservoir, oil relief valve, oil

piping, oil-pressure gauge, tachometer, and gland-seal piping if a condensing turbine is used. If a non-condensing turbine is used, provision shall be made for drain piping. The turbine shall be suitable for automatic control. An overspeed trip governor shall be provided to shut off the steam supply at 115 percent of design speed. Provision shall be made to stop the turbine upon operation of the compressor safety devices and upon power failure by the use of a solenoid trip on the emergency overspeed governor. Turbine shall be governed by a pneumatically controlled hydraulic governor during automatic operation and with a manual control effective during failure of the air supply. Pneumatic valve shall be actuated by a temperature controller with its sensing element in contact with the chilled water. Turbine shall be designed to operate at the steam pressure and exhaust conditions indicated. If the turbine is a condensing type, a surface-type steam condenser complete with single-stage air ejector, inter- and after-condenser, electric-driven dual condensate pumps, atmospheric relief valve, and expansion joint shall be furnished.

2.6.9 Compressor Driver Connections

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NOTE: Delete the first set of brackets if a large liquid-chilling package is specified. Delete the second set of brackets if a condensing and compressing unit or a small liquid-chilling package is used.

****

[Each compressor shall be driven by a V-belt drive or direct connected through a flexible coupling, except that flexible coupling is not required on hermetic units. V-belt drives shall be designed for not less than 150 percent of the driving motor capacity. Flexible couplings shall be of the type that does not require lubrication.] [Each machine driven through speed-increasing gears shall be so designed as to assure self-alignment, interchangeable parts, proper lubrication, and minimum of unbalanced forces. Bearings shall be of the sleeve or roller type. Pressure lubrication with pump and cooler shall be provided. Gear cases shall be oil tight. Shaft extensions shall be provided with seals to retain oil and exclude all dust.]

2.6.10 Liquid Cooler (Evaporator)

Cooler shall be of the shell-and-coil or shell-and-tube type design. Condenser's refrigerant side shall be designed and factory pressure tested to comply with ASHRAE 15. Condenser's water side shall be designed and factory pressure tested for not less than [1,000 kPa 150 psi] [1,700 kPa 250 psi]. Cooler shell shall be constructed of seamless or welded steel. Coil bundles shall be totally removable and arranged to drain completely. Tubes shall be seamless copper, plain, integrally finned with smooth bore or integrally finned with enhanced bore. Each tube shall be individually replaceable. Tubes shall be installed into carbon mild steel tube sheets by rolling. Tube baffles shall be properly spaced to provide adequate tube support and cross flow. Performance shall be based on a water velocity not less than 0.91 m/s (3 fps) 3 fps nor more than 3.7 mm (12 fps) 12 fps and a fouling factor of [0.00025] [0.0005].

2.6.11 Air-Cooled Condenser Coil

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NOTE: Standard coil construction is copper tubes with aluminum fins. For excessively corrosive atmospheres, either copper tubes with copper fins or aluminum tubes with aluminum fins should be considered. For additional corrosion protection, specify the manufacturer's standard epoxy or vinyl coating.

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Condenser coil shall be of the extended-surface fin-and-tube type and shall be constructed of seamless [copper] [or] [aluminum] tubes with compatible [copper] [or] [aluminum] fins. Fins shall be soldered or mechanically bonded to the tubes and installed in a metal casing. Coils shall be circuited and sized for a minimum of 3 degrees C 5 degrees F subcooling and full pumpdown capacity. Coil shall be factory leak and pressure tested after assembly in accordance with ASHRAE 15. [Coil shall be entirely coated with the manufacturer's standard epoxy or vinyl coating.]

2.6.12 Water-Cooled Condenser Coil

Condenser shall be of the shell-and-coil or shell-and-tube type design. Condenser's refrigerant side shall be designed and factory pressure tested to comply with ASHRAE 15. Condenser's water side shall be designed and factory pressure tested for not less than [1,000 kPa 150 psi] [1,700 kPa 250 psi]. Condensers shall be complete with pressure relief valve or rupture disk, water drain connections, and refrigerant charging valve. Low pressure refrigerant condenser shall be provided with a purge valve located at the highest point in the condenser to purge non-condensibles trapped in the condenser. Condenser shell shall be constructed of seamless or welded steel. Coil bundles shall be totally removable and arranged to drain completely. Tubes shall be seamless copper, plain, integrally finned with smooth bore or integrally finned with enhanced bore. Each tube shall be individually replaceable, except for the coaxial tubes. Tube baffles shall be properly spaced to provide adequate tube support and cross flow. Performance shall be based on water velocities not less than 0.91 m/s (3 fps) 3 fps nor more than 3.7 mm (12 fps) 12 fps and a fouling factor of [0.00025] [0.0005].

2.6.13 Heat Recovery Condenser Coil

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NOTE: The designer will conduct feasibility studies to determine if a heat recovery condenser is an economical addition to the system. Heat recovery condensers generally come in two sizes. The smaller of the two is generally sized to reject the superheat to the domestic water. The larger is sized to reject the same amount of heat as the standard condenser. The drawings will indicate the heat rejection capacity of the heat recovery

condenser and the temperatures of the water to which it must reject the heat.

****

Condenser shall be of the shell-and-coil or shell-and-tube type design and shall not be a part of the standard condenser. Condenser shall be provided and installed by the chiller manufacturer. Condenser's refrigerant side shall be designed and factory pressure tested to comply with ASHRAE 15. Condenser's water side shall be designed and factory pressure tested for not less than [1,000 kPa 150 psi] [1,700 kPa 250 psi]. Condenser shall have performance characteristics as indicated on the drawings. Condenser shell shall be constructed of seamless or welded steel. Coil bundles shall be totally removable and arranged to drain completely. Tubes shall be seamless copper, plain, integrally finned with smooth bore or integrally finned with enhanced bore. Each tube shall be individually replaceable, except for the coaxial tubes. Tube baffles shall be properly spaced to provide adequate tube support and cross flow. Performance shall be based on water velocities not less than 0.91 m/s (3 fps) 3 fps nor more than 3.7 mm (12 fps) 12 fps and a fouling factor of[0.00025] [0.0005].

2.6.14 Receivers

Liquid receivers not already specified herein as an integral factory-mounted part of a package, shall be designed, fitted, and rated in accordance with the recommendations of ARI 495, except as modified herein. Receiver shall bear a stamp certifying compliance with ASME BPV VIII Div 1 and shall meet the requirements of ASHRAE 15. Inner surfaces shall be thoroughly cleaned by sandblasting or other approved means. Each receiver shall have a storage capacity not less than 20 percent in excess of that required for the fully-charged system. Each receiver shall be equipped with inlet, outlet drop pipe, drain plug, purging valve, relief valves of capacity and setting required by ASHRAE 15, and two bull's eye liquid-level sight glasses. Sight glasses shall be in the same vertical plane, 90 degrees apart, perpendicular to the axis of the receiver, and not over 75 mm 3 inches horizontally from the drop pipe measured along the axis of the receiver. In lieu of bull's eye sight glass, external gauge glass with metal glass guard and automatic closing stop valves may be provided.

2.6.15 Chiller Purge System

****

NOTE: Refrigeration systems which operate below atmospheric pressure (i.e., R-123 machines) will require a refrigerant purge piping system. Indicate the routing of the piping on the drawings. Require the Contractor to delete the piping if a purge system is not required for the type of chiller that is to be provided. Indicate that it will be the Contractor's responsible to size the piping based upon the chiller manufacturer's recommendations. Purge discharge piping may be connected to the pressure-relief piping on the chiller side of the piping's vibration isolators.

****

Chillers which operate at pressures below atmospheric pressure shall be provided with a purge system that operates independently of the chiller. Purge system shall automatically remove air, water vapor, and non-condensible gases from the chiller's refrigerant. Purge system shall condense, separate, and return all refrigerant back to the chiller. An oil separator shall be provided with the purge system if required by the manufacturer. Purge system shall not discharge to occupied areas, or create a potential hazard to personnel. Purge system shall include a purge pressure gauge, number of starts counter, and an elapsed time meter. Purge system shall include lights or an alarm which indicate excessive purge or an abnormal air leakage into chiller.

2.6.16 Tools

One complete set of special tools as recommended by the manufacturer for field maintenance of the system shall be provided. Tools shall be mounted on a tool board in the equipment room or contained in a toolbox as directed by the Contracting Officer.

2.7 ABSORPTION LIQUID CHILLER

****

NOTE: Perform a life cycle cost analysis to determine the most economical type (single- or two-stage) of absorption unit to specify. The initial cost of a two-stage chiller is typically much higher than a single-stage machine, however a two-stage chiller will provide a substantial amount of energy savings over the life of the equipment.

Minimum efficiencies will either be presented in this paragraph or on the design drawings. Delete the efficiency ratings in this paragraph if equipment efficiencies are shown on the drawings. If the efficiencies are shown on the drawings, reference the applicable ARI standard. The following is a list of appropriate minimum full load and part load ratings for absorption chillers. These values or higher values will be entered into the specification where indicated. The designer should contact manufacturers to determine what is available before specifying full and part load values.

	Full Load (*COP)	IPLV (*COP)
Single Effect (Indirect Fired):		
All Capacities	**0.65**	**0.65**
Double Effect (Indirect Fired):		
All Capacities	**1.20**	**1.25**

	Full Load (*COP)	IPLV (*COP)
Double Effect (Direct Fired):		
All Capacities	**0.90**	**0.90**

*** - Units are dimensionless (output / input)**
****

Chiller shall be constructed and rated in accordance with ARI 560 and shall bear the appropriate underwriter's laboratories (UL) label. [Chiller shall have a minimum cooling Coefficient of Performance (COP) of [_____] at full load conditions in accordance with ARI 560. Chiller shall have a minimum cooling COP of [_____] at part load conditions in accordance with ARI 560.] Chiller shall be the [single-stage] [two-stage] hermetic, water-cooled type design. Chiller shall be [indirectly-fired with [steam] [hot water]] [directly-fired with a [single] [dual] fuel burner]. [For direct-fired units, ratings for cooling capacity, fuel consumption, and COP shall be based on the higher heating value (HHV) or the specific type of fuel utilized.] Unless necessary for delivery purposes, chiller shall be assembled, leak-tested, charged, and adjusted at the factory. In lieu of delivery constraints, a chiller may be assembled, leak-tested, charged, and adjusted at the job site by a factory representative. Unit components delivered separately shall be sealed and charged with a nitrogen holding charge. Unit assembly shall be completed in strict accordance with manufacturer's recommendations. Chiller shall operate within capacity range and speed recommended by the manufacturer. Parts weighing 23 EKG 50 pounds or more which must be removed for inspection, cleaning, or repair shall have lifting eyes or lugs. Chiller shall be provided with factory installed insulation on surfaces subject to sweating including the liquid cooler and water boxes. Chiller shall be provided from the factory with a single point wiring connection for incoming power supply. Magnetic across-the-line motor starters with overload protection shall be provided for each factory supplied pump. Chiller shall include all customary auxiliaries deemed necessary by the manufacturer for safe, controlled, automatic operation of the equipment. Chiller shall include the following as a minimum:

a. Absorber, evaporator, and condenser

b. [Generator] [First and second stage generators]

c. Refrigerant, absorber, and inhibitor solutions

d. [Low] [Low and high] temperature heat exchanger(s)

e. Self-contained, hermetically sealed, self lubricating, liquid cooled, refrigerant and solution pumps. Pumps shall be direct coupled with the motor and shall include isolation valves.

f. [Combustion burner assembly and pre-piped fuel train]

g. [Cooling/heating switch valve]

h. [Exhaust gas economizer]

i. Automatic purge system

j. Automatic decrystallization system

k. Chiller controls package

l. Interconnecting piping and wiring

m. [Standard] [Marine] water boxes with [grooved mechanical] [flanged] [welded] connections

n. Refrigerant spray nozzles

o. Factory-mounted welded structural steel base.

p. Thermometers and sight glasses to allow visual inspection of unit operation

2.7.1 Component Construction

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NOTE: Delete the requirements for the first and second stage generators if a two-effort chiller is not specified.
****

Chiller exterior surfaces shall be factory painted, finished, and insulated as applicable. Chiller shell shall be of seamless or welded steel construction with cast iron or welded steel heads. Evaporator, absorber, condenser, generator(s), and heat exchanger(s) shall be of the shell-and-tube type construction and be in accordance with ASME BPV VIII Div 1. Evaporator, absorber, condenser, and heat exchanger tubes shall be shall be seamless copper or cupronickel (CuNi). [First stage generator tubes shall be seamless carbon steel or type 409 stainless steel. Second stage generator] [Generator] tubes shall be seamless copper-nickel. Tubes shall be individually replaceable. Water boxes shall be provided with lifting lugs, gasketed removable covers, drains, and vents. Unit's internal waterside components shall be rated for not less than 1,000 kPA (150 psig) 150 psig and factory tested at 150 percent of design working pressure. Factory installed insulation shall be provided for the refrigerant pump, all exposed chilled water piping, the absorber shell, the steam or hot water inlet piping, and the condensate or hot water outlet piping shall be insulated per manufacturer's standard practice. Chiller shall be provided with [standard] [marine] water boxes with [grooved mechanical] [flanged] [welded] connections.

2.7.2 Combustion Burner Assembly

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NOTE: Delete this paragraph if a direct-fired absorption chiller is not specified.
****

Chiller shall be provided with a forced draft, flame retention type burner and fuel train assembly. Burner shall be the [single] [dual] fuel type capable of burning [natural gas] [propane] [and] [number 1 fuel oil] [number 2 fuel oil] [diesel]. Burner and fuel train shall be listed by the underwriters laboratories (UL). Burner assembly shall be provided with all pressure regulators, switches, controls, ignition system, blower fans, and other devices required for proper and safe operation of the burner. Burner assembly shall be equipped with an external primary-secondary air ratio adjustment that allows adjustment without dismantling the burner. Burner controls shall allow either manual or automatic burner operation. Fuel changeover shall be accomplished [by a manual fuel changeover switch] [automatically as indicated].

2.7.3 Controls Package

Chiller shall be provided with a complete factory mounted and prewired electric or microprocessor based control system. Controls package shall be [unit-mounted] [floor-mounted where indicated] which contains as a minimum a digital display or acceptable gauges, an on-auto-off switch, motor starters, power wiring, control wiring, and disconnect switches. Controls package shall provide operating controls, monitoring capabilities, programmable setpoints, safety controls, and EMCS interfaces as defined below.

2.7.3.1 Operating Controls

Chiller shall be provided with the following adjustable operating controls as a minimum.

a. Leaving chilled water temperature control

b. System capacity control to adjust the unit capacity in accordance with the system load and the programmable setpoints. Controls shall automatically re-cycle the chiller on power interruption.

2.7.3.2 Monitoring Capabilities

During normal operations, the control system shall be capable of monitoring and displaying the following operating parameters. Access and operation of display shall not require opening or removing any panels or doors.

a. Entering and leaving chilled water temperatures
b. Entering and leaving condenser water temperatures
c. Refrigerant and solution temperatures
d. Generator pressures and temperatures
e. Self diagnostic
f. Operation status
g. Operating hours
h. Number of starts
i. Number of purge cycles over the last 7 days

2.7.3.3 Programmable Setpoints

The control system shall be capable of being reprogrammed directly at the unit. No parameters shall be capable of being changed without first entering a security access code. The programmable setpoints shall include the following as a minimum.

a. Leaving Chilled Water Temperature
b. Leaving Condenser Water Temperature
c. Time Clock/Calender Date

2.7.3.4 Safety Controls with Manual Reset

Chiller shall be provided with the following safety controls which automatically shutdown the chiller and which require manual reset.

a. Refrigerant or solution pump thermal or current overload
b. Low refrigerant temperature
c. Loss of chilled water
d. Loss of condenser water
e. High or low condenser water temperatures
f. Power failure
g. Generator high temperature or pressure
h. Low solution level
i. [Burner or related combustion malfunction]

2.7.3.5 Remote Alarm

During the initiation of a safety shutdown, the control system shall be capable of activating a remote alarm bell. In coordination with the chiller, the contractor shall provide an alarm circuit (including transformer if applicable) and a minimum 100 mm (4 inch) 4 inch diameter alarm bell. Alarm circuit shall activate bell in the event of machine shutdown due to the chiller's monitoring of safety controls. The alarm bell shall not sound for a chiller that uses low-pressure cutout as an operating control.

2.7.3.6 Energy Management Control System (EMCS) Interface

The control system shall be capable of communicating all data to a remote integrated DDC processor through a single shielded cable. The data shall include as a minimum all system operating conditions, capacity controls, and safety shutdown conditions. The control system shall also be capable of receiving at a minimum the following operating commands.

a. Remote Unit Start/Stop
b. Remote Chilled Water Reset
c. Remote Condenser Water Reset

2.8 ACCESSORIES

2.8.1 Pumps

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NOTE: Indicate on the drawings pump capacity, efficiencies, motor sizes, and impeller types.

Typical impeller types include the double-suction horizontal split-case type, end-suction vertical split-case type, close-coupled end-suction type, close-coupled in-line type.

****

Pumps shall be the electrically driven, non-overloading, centrifugal type which conform to HI 1.1-1.5. Pump capacity, efficiency, motor size, and impeller type shall be as indicated on the drawings. Pumps shall be selected at or near peak efficiency. Pump curve shall rise continuously from maximum capacity to shutoff. Pump motor shall be totally enclosed and have sufficient wattage (horsepower) horsepower for the service required. Each pump motor shall be equipped with an across-the-line magnetic controller in a NEMA 250, Type 1 enclosure with "START-STOP" switch in the cover.

2.8.1.1 Construction

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NOTE: In most cases, mechanical shaft seals will be the preferred type of shaft seal rather than the stuffing-box type. Although less costly in many cases, the stuffing-box type seals require periodic maintenance rendering the seals economical typically only for very large pumps where the first cost difference is great. The designer should make an economic shaft seal selection based on life cycle cost.

****

Shaft seal shall be mechanical-seal or stuffing-box type. Impeller shall be statically and dynamically balanced. Each pump casing shall be designed to withstand the discharge head specified plus the static head on system plus 50 percent of the total, but not less than 862 kPa (125 psig).125 psig. Pump casing and bearing housing shall be close grained cast iron. High points in the casing shall be provided with manual air vents; low points shall be provided with drain plugs. Impeller, impeller wearing rings, glands, casing wear rings, and shaft sleeve shall be bronze. Shaft shall be carbon or alloy steel, turned and ground. Bearings shall be ball-bearings, roller-bearings, or oil-lubricated bronze-sleeve type bearings, and be efficiently sealed or isolated to prevent loss of oil or entrance of dirt or water. [Pump and motor shall be mounted on a common cast iron base having lipped edges and tapped drainage openings or structural steel base with lipped edges or drain pan and tapped drainage openings.] [Pump shall be provided with shaft coupling guard.] [Close coupled pumps shall be provided with drip pockets and tapped openings.] Pump motor shall have the required capacity to prevent overloading with pump operating at any point on its characteristic curve. Pump speed shall not exceed 3,600 rpm, except where the pump head is less than 180 kPa, 60 feet of water, the pump speed shall not exceed 1,750 rpm. Pump shall be accessible for servicing without disturbing piping connections.

2.8.1.2 Mechanical Shaft Seals

Seals shall be single, inside mounted, end-face-elastomer bellows type with stainless steel spring, brass or stainless steel seal head, carbon rotating face, and tungsten carbide or ceramic sealing face. Glands shall be bronze and of the water-flush design to provide lubrication flush across the face of the seal. Bypass line from pump discharge to flush connection in gland shall be provided, with filter or cyclone separator in line.

2.8.1.3 Stuffing-Box Type Seals

Stuffing box shall include minimum 4 rows of square, impregnated TFE (Teflon) or graphite cord packing and a bronze split-lantern ring. Packing gland shall be bronze interlocking split type.

2.8.2 Expansion Tanks

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NOTE: Designer will indicate the location and size of each expansion tank on the drawings.
****

Expansion tanks shall be welded steel, constructed, tested and stamped in accordance with ASME BPV VIII Div 1 for a working pressure of 862 [_____] kPa (125 [_____] psig) 125 [_____] psig and precharged to the minimum operating pressure. Expansion tanks shall have a replaceable diaphragm and be the captive air type. Tanks shall accommodate expanded water of the system generated within the normal operating temperature range, limiting this pressure increase at all components in the system to the maximum allowable pressure at those components. Each tank air chamber shall be fitted with an air charging valve. Tanks shall be supported by steel legs or bases for vertical installation or steel saddles for horizontal installations. The only air in the system shall be the permanent sealed-in air cushion contained within the expansion tank.

2.8.2.1 Acceptable Manufacturers of Expansion Tanks

Armstrong Pumps, Inc., Model [_____].
Bell & Gossett Corp., Model [_____].
Taco, Inc., Model [_____].
Or an approved equal in accordance with section 00700, Materials and Workmanship.

2.8.3 Air Separator Tanks

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NOTE: The designer will indicate the location and the minimum size of each air separator on the drawings.
****

External air separation tank shall be steel, constructed, tested, and stamped in accordance with ASME BPV VIII Div 1 for a working pressure of 862 [_____] kPa (125 [_____] psig).[125] [_____] psig.

2.8.4 Refrigerant Leak Detector

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NOTE: Refrigerant leak detectors will be provided as required by the "System Application Requirements" in ASHRAE 15.

When a detector is required, the location will be indicated on the drawings. Detectors are best located between the refrigeration system and the room exhaust. Sampling points from a detector will be located a maximum of 18 inches above the finished floor since all commonly-used refrigerants are heavier than air.

As a rule of thumb, the distance between any refrigeration system and a refrigerant sampling point shouldn't exceed 50 feet. In order to meet the recommended 50 foot distance, a mechanical room can be provided with either multiple detectors each with single sampling points or with one detector that has the capability of monitoring at multiple sampling points. If multiple sampling points are required, enter the number in the appropriate blank below.

Per ASHRAE 15, when a detector senses refrigerant it must activate an alarm and initiate the room ventilation system. In regards to alarms, as a minimum, indicate that the detector will energize a light on or near the detector as well as a second light installed on the outside wall next to the mechanical room entrance. The exterior light will be provided with a sign that warns personnel entering the mechanical room of a refrigerant release and that a SCBA is required to enter. If applicable to the installation, include an audible alarm on the exterior of the mechanical room. Include the electrical design for the alarm system on the drawings.

As an additional item, ASHRAE 15 states that open-flame devices (i.e., boilers, etc.) cannot be installed in the same area as a refrigeration system, unless either combustion air for the open-flame device is ducted straight from outside to the device; or the alarm relay from the detector is used to automatically shutdown the combustion process in the event of refrigerant leakage. Indicate all applicable alarm controls on the drawings.

Delete the information in the last bracketed sentences if an EMCS is not applicable to the design.

****

Detector shall be the continuously-operating, halogen-specific type. Detector shall be appropriate for the refrigerant in use. Detector shall be specifically designed for area monitoring and shall include [a single sampling point] [_____ sampling points] installed where indicated. Detector design and construction shall be compatible with the temperature, humidity, barometric pressure and voltage fluctuations of the operating area. Detector shall have an adjustable sensitivity such that it can detect refrigerant at or above 3 parts per million (ppm). Detector shall be supplied factory-calibrated for the appropriate refrigerant(s). Detector shall be provided with an alarm relay output which energizes when the detector detects a refrigerant level at or above the TLV-TWA (or toxicity measurement consistent therewith) for the refrigerant(s) in use. The detector's relay shall be capable of initiating corresponding alarms and ventilation systems as indicated on the drawings. Detector shall be provided with a failure relay output that energizes when the monitor detects a fault in its operation. [Detector shall be capable with the facility's energy management and control system (EMSS). The EMCS shall be capable of generating an electronic log of the refrigerant level in the operating area, monitoring for detector malfunctions, and monitoring for any refrigerant alarm conditions.]

2.8.5 Refrigerant Relief Valve/Rupture Disc Assembly

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NOTE: ASHRAE 15 requires refrigeration systems to be protected with a pressure-relief device that will safely relieve pressure due to fire or other abnormal conditions. A relief valve/rupture disc assembly is the optimum solution. The rupture disc will provide visual indication of a release while also providing immediate shutoff once a safe pressure is achieved.

Designer will indicate on the drawings the location of each new relief valve/rupture disc assembly as well as the routing and size of corresponding pressure-relief piping. The routing and size of new pressure-relief piping will be per ASHRAE 15.

****

The assembly shall be a combination pressure relief valve and rupture disc designed for refrigerant usage. The assembly shall be in accordance with ASME BPV IX and ASHRAE 15. The assembly shall be provided with a pressure gauge assembly which will provide local indication if a rupture disc is broken. Rupture disc shall be the non-fragmenting type.

2.8.6 Refrigerant Signs

Refrigerant signs shall be a medium-weight aluminum type with a baked enamel finish. Signs shall be suitable for indoor or outdoor service. Signs shall have a white background with red letters not less than 12 mm 0.5 inches in height.

2.8.6.1 Installation Identification

Each new refrigerating system shall be provided with a refrigerant sign which indicates the following as a minimum:

a. Contractor's name.
b. Refrigerant number and amount of refrigerant.
c. The lubricant identity and amount.
d. Field test pressure applied.

2.8.6.2 Controls and Piping Identification

Refrigerant systems containing more than 50 kg 110 lb of refrigerant shall be provided with refrigerant signs which designate the following as a minimum:

a. Valves or switches for controlling the refrigerant flow [, the ventilation system,] and the refrigerant compressor(s).

b. Pressure limiting device(s).

2.8.7 Refrigerant Recovery/Recycle System

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NOTE: A refrigerant recovery/recycle system will not be specified if the designer determines that on site staff will not be responsible for chiller teardown or major service. If the designer determines the on site staff will be responsible for chiller teardown or major service, the designer shall investigate whether another recovery/recycle system is available to maintenance personnel before specifying a new system. The recovery/recycle system is an expensive item and all alternatives to providing a new system should be investigated.

If a refrigerant recovery/recycle system is specified, the recovery/recycle system shall be tested and listed to conform to the requirements of ARI 740 for refrigerant recovery/recycle systems by a recognized national testing laboratory. The system shall include separate storage vessel(s) capable of storing the entire refrigerant charge of the largest chiller.

The recovery/recycle unit shall be portable. Chiller mounting or floor mounting of the system is expensive and therefore is discouraged.

****

A manually initiated refrigerant recovery/recycle system shall be provided, consisting of a motor-driven, air- or water-cooled, reciprocating condensing unit and a receiver of sufficient capacity to store the entire refrigerant charge of the largest water-chilling system. For refrigerants

with atmospheric pressure boiling temperature below 20 degrees C, 68 degrees F, the receiver shall be sized so that it is no more than 80 percent full at 32 degrees C. 90 degrees F. For refrigerants with atmospheric pressure boiling temperature above 20 degrees C, 68 degrees F, the receiver shall be sized so that it is no more than 90 percent full at 32 degrees C.90 degrees F. The recovery/recycle system condensing unit shall be assembled as a complete unit and meet the requirements of ASHRAE 15. The system components shall be portable and shall include all valves, connections, and controls required for operation. Receiver and relief devices shall conform to the requirements of ASME BPV VIII Div 1. The recovery/recycle system shall be tested and listed to conform to ARI 740 for refrigerant recovery/recycle systems by a recognized national testing laboratory. For refrigerants with atmospheric pressure boiling temperature below 20 degrees C,68 degrees F, the recovery/recycle unit shall have an ARI 740 vapor refrigerant recovery rate of no less than 8.5 kg/minute.17.0 lb/minute. For refrigerants with atmospheric pressure boiling temperature above 20 degrees C,68 degrees F, the recovery/recycle unit shall have an ARI 740 vapor refrigerant recovery rate of no less than 1.0 kg/minute.2.2 lb/minute.

2.8.8 Automatic Tube Brush Cleaning System

****

NOTE: Condensing steam-turbine-driven machines, with refrigeration and steam condensing water flows in series, must be unloaded prior to condenser water flow reversal. In this, the designer will investigate the availability of controllers to unload the machine prior to flow reversal and mark up the specification accordingly.

Water flow diverters bypass approximately 3 percent of the total condenser water flow around the condenser. The designer will investigate condenser water bypass requirements and size the condenser water pumps and the chiller for the corrected condenser water flow.

****

2.8.8.1 Brush and Basket Sets

One brush and basket set (one brush and two baskets) shall be furnished for each condenser tube. Brushes shall be made of nylon bristles, with titanium wire. Baskets shall be polypropylene.

2.8.8.2 Flow-Diverter Valve

Each system shall be equipped with one flow-diverter valve specifically designed for the automatic tube brush cleaning system and have parallel flow connections. The flow-diverter valve shall be designed for a working pressure of [1,000 kPa (150 psig)] [1,700 kPa (250 psig)].[150] [250] psig. End connections shall be flanged. Each valve shall be provided with an electrically operated air solenoid valve and position indicator.

2.8.8.3 Control Panel

The control panel shall provide signals to the diverter valve at a preset time interval to reverse water flow to drive the tube brushes down the tubes and then signal the valve to reverse the water flow to drive the brushes back down the tubes to their original position. The controller shall have the following features as a minimum:

a. Timer to initiate the on-load cleaning cycle.
b. Manual override of preset cleaning cycle.
c. Power-on indicator.
d. Diverter-position indicator.
e. Cleaning-cycle-time adjustment
f. Flow-switch bypass.

2.8.9 Field Installed Insulation

Field installed insulation shall be as specified in Section 15080 THERMAL INSULATION FOR MECHANICAL SYSTEMS, except for header and waterbox insulation which shall be flexible cellular insulation in accordance with ASTM C 534, Type I.

2.8.10 Gaskets

Gaskets shall conform to ASTM F 104 - classification for compressed sheet with nitrile binder and acrylic fibers for maximum 371 degrees C (700 degrees F) 700 degrees F service.

2.8.11 Bolts and Nuts

Bolts and nuts, except as required for piping applications, shall be in accordance with ASTM A 307. The bolt head shall be marked to identify the manufacturer and the standard with which the bolt complies in accordance with ASTM A 307.

2.9 COOLING TOWER

****

NOTE: Locate the tower in accordance with NFPA 214, and determine the extent and type of fire protection required for all size towers using the factors indicated in NFPA 214. Concrete structured towers are selected for their longevity over conventional type, but are considerably more expensive and should be used only if cost effective. PVC fill for concrete towers is considerably less expensive and should be specified unless tile fill can be justified. When project requirements limit the use of wood construction in cooling towers, all references to wood construction will be removed.

****

2.9.1 Fire Safety

Towers shall conform to NFPA 214. Fire hazard rating for plastic impregnated materials shall not exceed 25. Plastics shall not drip or run during combustion. Determine ratings by ASTM E 84 or NFPA 255.

2.9.2 Lumber

Lumber required for cooling tower construction shall be as defined by the following type woods:

2.9.2.1 Douglas Fir

CTI Std-114, WWPA Grading Rules, Grade B and better, Industrial Clear. Douglas fir shall have a preservative treatment in accordance with CTI Std-112.

2.9.2.2 Plywood

CTI Std-134, Exterior Grade, type and thickness as specified for the application.

2.9.2.3 Pressure Treated Lumber

Pressure treated lumber shall be in accordance with CTI Std-112. Wood exposed as the result of notching, cutting, or drilling shall be saturated with the preservative.

2.9.2.4 Redwood

CTI Std-103, CRA RIS-01-SS California Redwood, clear of all hearts.

2.9.3 Fiberglass Reinforced Plastic (FRP)

FRP components shall be inert, corrosion resistant, and fire-retardant with a thickness of 3.66 kg/square meter (12 ounces per square foot).12 ounces per square foot. FRP components shall contain an ultraviolet (UV) ray inhibitor as per CTI Std-137, Grade 1 or 3.

2.9.4 Zinc-Coated Steel

Components fabricated of zinc-coated steel shall be not lighter than 16 gauge steel, protected against corrosion by a zinc coating. The zinc coating shall conform to ASTM A 153/A 153M and ASTM A 123/A 123M, as applicable and have an extra heavy coating of not less than 0.76 kg per square meter (2-1/2 ounces per square foot) 2-1/2 ounces per square foot of surface. Galvanized surfaces damaged due to welding shall be coated with zinc rich coating conforming to ASTM D 520, Type 1.

2.9.5 Polyvinyl Chloride (PVC) Formed Sheets

ASTM D 1784, Type I, Grade 1 with a flame spread rating of 15 or less per ASTM E 84.

2.9.6 Hardware

Bolts shall be cadmium-plated, zinc-coated steel, or Type 304 stainless steel. Each bolt shall be provided with neoprene and cadmium-plated steel washers under the heads. Nails shall be silicon bronze, commercial bronze, or stainless steel. Hardware shall meet the salt-spray fog test as defined by ASTM B 117.

2.9.7 Noise Control

****

NOTE: Where cooling towers are in the proximity of residential, administrative, medical, or similar inhabited facility, the maximum acceptable noise limits for such applications should be determined in NC level or dBA, and coordinated with local code requirements and the cooling tower manufacturer. The noise level criteria should be scheduled on the drawing.

****

Sound power levels (in decibels with a reference pressure of 0.0002 microbar) of the cooling tower shall not exceed the maximum permitted decibel levels for the designated octave band as set forth in the following tables. Sound power level data for the cooling tower shall be based on tests conducted in accordance with ANSI S1.13.

Octave Band (in Hz)	63	125	250	500	1000	2000	4000	8000
Sound Power Level in dB	[_____]	[_____]	[_____]	[_____]	[_____]	[_____]	[_____]	[_____]

2.9.8 Conventional Type Tower

a. Factory-Assembled: Each tower shall be the induced mechanical draft, [crossflow] [or] [counterflow], factory fabricated, factory-assembled type.

b. Field-Assembled: Each tower shall be the induced mechanical draft, [crossflow] [or] [counterflow], factory fabricated, field-assembled type. Notching structural members may be permissible only if the members are increased proportionately in size to provide equivalent strength. Framework design for wood towers shall conform to requirements of CTI Std-103 for redwood construction and CTI Std-114 for douglas fir construction.

2.9.8.1 Casing

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NOTE: Delete the last two sentence if inapplicable.

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Casing shall be constructed of [zinc-coated steel] [lumber] [Type 304 stainless steel] [FRP]. Towers shall be designed and constructed to withstand a wind pressure of not less than 1.4 KPa (30 pound-force per

square foot (psf)) 30 pound-force per square foot (psf) on external surfaces. Fan decks shall be designed to withstand a live load of not less than [1.9] [2.9] kPa ([40] [60] psf) [40] [60] psf in addition to the concentrated or distributed loads of equipment mounted on the fan decks. A 15-percent increased loading shall be included for ice or snow load. Air inlet and discharge terminations shall have flanged or lipped projections for connecting ductwork.

2.9.8.2 Cold-Water Basin

Basin shall be completely watertight and constructed of [36 mm (1-1/2 inch) 1-1/2 inch tongue and groove lumber] [concrete in accordance with Section 03300 CAST-IN-PLACE STRUCTURAL CONCRETE, 1.38 MPa (2,500 psi) 2,500 psi Class and reinforced as indicated.] [Type 304 stainless steel] [FRP]. Basin shall be constructed and installed to ensure that air will not be entrained in outlets when operating and no water will overflow on shutdown. Each individual sump shall be provided with an individual outlet. Each outlet shall be provided with a 1/2 inch mesh, zinc-coated steel wire securely mounted to prevent trash from entering the outlet. Each basin shall be provided with overflow and valved drain connections. Each basin shall be provided with a float-controlled, makeup water valve as indicated. The makeup water shall discharge not less than 50 mm 2 inches or two pipe diameters, whichever is greater, above the top of the basin.

2.9.8.3 Hot-Water Distribution

Design water distribution systems for each cell of each tower so that a water flow of 140 percent of specified water flow will not cause overflowing or splashing. Water distribution systems shall be accessible and permit flexibility of operation. Provide removable covers of same material and thickness as casing for entire water distribution basin. Support covers by basin sides with top of cover flush with top of basin. Provide separate regulation and stop valves for complete balancing and complete shutoff from each cell. Systems shall be self-draining and nonclogging. The water distribution system shall be either one of the following types.

a. Open Basins: Basins shall be provided with a splash box or baffles to minimize splashing of incoming hot water, holes that evenly distribute the water over the entire decking area, and a basin cover. Holes used in a water basin shall be provided with ceramic or plastic orifice inserts.

b. Spray Nozzles: Spray nozzles shall be cleanable; stainless steel, bronze, or high-impact plastic, nonclogging, removable; and, spaced for even distribution.

2.9.8.4 Fill Material

The fill shall be the following materials as specified. PVC formed sheets arranged in a honeycomb or waveform configuration; zinc-coated steel treated Douglas-fir; or treated hemlock and treated redwood. Zinc-coated steel shall have a minimum of 765 g per square meter 2.5 ounces per square foot of surface. Fill material shall be free to expand or contract without

warping. PVC fill shall not be provided when inlet temperatures exceed 52 degrees C (125 degrees F).125 degrees F. No plasticized wood cellulose shall be provided for fill material. Fill shall be removable or otherwise made accessible for cleaning. Provide space supports as required to prevent sagging and misalignment, and provide for an even mixing of air and water.

2.9.8.5 Drift Eliminator

Provide in tower outlet to limit drift loss to not over 0.02 percent of specified water flow. Eliminators shall be constructed of not less than 10 mm (3/8 inch) 3/8 inch lumber or polyvinyl chloride (PVC).

2.9.8.6 Fan Cylinder

Each fan shall be mounted in a fan cylinder to elevate the fan discharge air. Total extension height shall not exceed the fan diameter. Fan cylinders shall be constructed of zinc-coated steel, lumber, Type 304 stainless steel, or FRP and be compatible with the entire tower construction. Each fan cylinder shall be provided with a zinc-coated steel 2.75 mm (12 gauge) 12 gauge wire mesh securely mounted to the top of the cylinder in accordance with manufacturer's recommendations.

2.9.8.7 Framework and Equipment Supports

Framework and equipment supports shall be zinc-coated steel [, Type 304 stainless steel,] [FRP,] or lumber. Materials provided for framework, casings and equipment supports shall be compatible.

2.9.8.8 Structural Supports

Structural supports shall be provided in accordance with the recommendations of the manufacturer of the tower unless otherwise indicated.

2.9.8.9 Foundations

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NOTE: For the design of a tower foundation, indicate the location, the size, the reinforcement requirements, etc. necessary for a cooling tower available from three commonly known manufacturers. For small retrofit type jobs the designer may choose to show the general layout of the foundation and rely on the Contractor to design and construct the foundation based on the cooling tower to be provided. Delete the last two sentences of the paragraph if the foundation is not to be designed by the Contractor.

****

Cooling tower foundations shall meet the requirements of the cooling tower manufacturer and be as indicated. Foundation design shall be based on the load conditions and soil bearing value indicated. Foundation calculations shall be submitted with the equipment drawings.

2.9.8.10 Acceptable Manufacturers of Cooling Towers

Baltimore Aircoil Co., Model [_____].
Evapco, Inc., Model [_____].
Marley Cooling Tower Co., Model [_____].
Or an approved equal in accordance with section 00700, Materials and Workmanship.

2.9.9 Concrete Structured Type

Each tower shall be the induced mechanical draft, counterflow, factory fabricated, field-assembled type.

2.9.9.1 Casing

The wall sections shall be constructed of air entrained concrete mix. Concrete shall conform to Section 03300 CAST-IN-PLACE STRUCTURAL CONCRETE. Exposed concrete shall be rub-finished for smooth and uniform surfaces free of form marks and defects. Honeycomb concrete shall not be permitted. Any cold-pour joints in vertical walls shall have a continuous water-stop stripping of molded polyvinyl plastic (150 mm 6 inch dumbbell).

2.9.9.2 Cold-Water Basin

Basin floor slab shall be a continuous pour of high density air entrained concrete. The mix shall be of a strength to test a minimum of 27.6 MPa (4,000 psi) 4,000 psi (28 days) compressive. Air entrained cement, conforming to Section 03300 CAST-IN-PLACE STRUCTURAL CONCRETE shall be used throughout the tower structure. Structure shall contain the reinforcing steel as detailed. Standard curing measures shall be carried out to protect the concrete while "green". Exposed concrete shall be rub-finished for smooth and uniform surfaces free of form marks and defects. Honeycomb concrete shall not be permitted. A continuous water-stop stripping of molded polyvinyl plastic (150 mm 6 inch dumbbell) shall be located on the centerline position of the basin wall section/floor slab intersection, and at all other cold pour joints. Basin wall sections shall be made in a second continuous pour, contain the necessary reinforcing steel as submitted by the manufacturer and approved, and be arranged to interlock with the water-stop seal in the floor slab, forming a completely waterproof basin.

2.9.9.3 Hot-Water Distribution

Distribution system for each cell shall consist of a centrally located header complete with junction boxes, side laterals, fittings, and nozzles. Piping shall be either cast iron, ductile iron, threaded-glass-fiber reinforced epoxy pipe, polypropylene, PVC or Schedule 80 black steel. Junction boxes shall be cast iron and nozzles shall be brass, stainless steel or plastic. Distribution piping including spray nozzles, pipe, fittings, and junction boxes shall be provided complete to flange face located at a point 150 mm 6 inches below top of fill support beam. Provisions shall be provided for balancing of water flow between cells or spray trees.

2.9.9.4 Fill Material

Fill material shall be [tile of multicell design, set without mortar] [or] [PVC formed sheets], in a pattern, and of sufficient height to meet the performance specifications. [Tile fill shall be vitreous, with a low water absorption that will pass a freeze-thaw test conducted in accordance with ASTM C 67. Tile fill shall have a minimum crushing strength of 13.8 MPa (2,000 psi) 2,000 psi over the gross area of the tile when the load is applied parallel to the cells as tested in accordance with ASTM C 67. Cast iron tee section lintels supporting the tile fill shall conform to ASTM A 48, ASTM A 48M, Class 25, 3.2 mm 1/8 inch additional thickness for corrosion. Lintels shall be designed with a safety factor of 2 minimum.] [PVC fill shall be manufactured from minimum nominal [0.5] [0.38] mm ([20] [15] mil) [20] [15] mil sheets. PVC fill shall be supported by the tower structure using corrosion resistant members. PVC sheets shall be arranged in a honeycomb or waveform configuration and shall have a flame spread rating of 25 or less when tested in accordance with ASTM E 84. Fill material shall be free to expand or contract without warping or cracking.]

2.9.9.5 Drift Eliminators

Eliminators shall be of the multi-pass zigzag type, assembled into sections making a strong, stable unit. Provide in tower outlet to limit drift loss to not over 0.005 percent of the water flow. These sections shall be supported on PVC or FRP tee sections. Tee sections shall be suspended with 6.35 mm (1/4 inch) 1/4 inch brass rods connected to stainless steel clips embedded in the bottom side of the roof deck at the time of casting. Stainless steel clips shall be supplied by cooling tower manufacturer for installation by Contractor at time of roof deck pour. Eliminators may be supported by brass or stainless steel suspension rods from the fan deck or supported directly on concrete beams. Eliminators may be either PVC extruded sections or wave formed sheets of PVC resin conforming to ASTM D 1784 Type I, Grade 2. Eliminators and supporting framework shall have flame spread rating of 25 or less when tested in accordance with ASTM E 84.

2.9.9.6 Fan Decks and Stacks

Construct fan decks of precast, reinforced lightweight concrete, in multiple sections, forming a complete, vibration-free base for mounting fan, speed reducer, drive shaft, motor, and fan stacks. Construct fan stacks of precast, reinforced lightweight concrete in multiple sections, constrained with bands of zinc-coated steel conforming to ASTM A 123/A 123M, not less than 3 x 75 mm (1/8 x 3 inches), 1/8 x 3 inches, and bolted to form a compressive load on stack perimeter. Secure stack in place on fan deck with Class A mortar.

2.9.10 Louvers

Air inlets for each cooling tower shall be provided with individually removable louvers arranged to prevent the escape of water. Louvers shall be zinc-coated steel, [Type 304 stainless steel,] [FRP,] or lumber. Materials provided for casings and louvers shall be compatible; one material shall not produce stains upon the other. Louvers constructed of

lumber shall be of a thickness to withstand alternate wetting and drying without cracking or splitting. Air intakes shall be provided with 25 mm 1 inch zinc-coated steel mesh.

2.9.11 Fans

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NOTE: When the density of the ambient air to be handled by the fans differs substantially from the density of the standard air value of 1.2 kg per cubic m (0.075 pound per cubic foot) at 21 degrees C (70 degrees F) and 101 kPa (29.92 inches mercury), the density of the air and/or the elevation above mean sea level will be stated.

****

Fans shall be the [centrifugal] [or] [adjustable-pitch propeller] type, constructed of zinc-coated steel, Type 304 stainless steel, aluminum or an aluminum alloy, or FRP. Propeller type shall have a maximum tip speed of 55 m (11,000 fpm).11,000 fpm. Fan blade assembly shall be both statically and dynamically balanced after assembly of the cooling tower. Fan hub shall be constructed of [zinc-coated steel] [stainless steel] [cast aluminum] with adequate surface protection against corrosion. Complete fan assembly (fan and mounting) shall be designed to give maximum fan efficiency and long life when handling saturated air at high velocities.

2.9.12 Speed Reducer Gears and Drive Shaft

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NOTE: Double reduction gear reducer should be considered where low noise requirement is a factor.

****

Speed reducer gears shall be rated in accordance with CTI Std-111. Gear reducers shall be of the [spiral bevel, single reduction] [spiral or helical, double reduction] type. Reducer shall be mounted in accordance with manufacturer's recommendations. Each reducer shall be provided with an oil level cutoff switch interlocked to the fan motor. Each reducer shall be provided with an oil level sight glass, fill, drain, and vent lines located in a readily accessible position. Drive shafts shall be the full floating type with flexible couplings at both ends and have a service factor of 1.0 or greater. Drive shafts shall be of stainless steel, fitted each end with flexible couplings (stainless steel plate type). Each drive shaft shall be provided with a galvanized steel guard, to prevent damage to surrounding equipment in case of shaft failure. Provision shall be made for lubrication of all bearings. Bearings shall be accessible to the extent that each bearing can be lubricated without dismantling fan.

2.9.13 Fan Motor

****

NOTE: Delete the last sentence if inapplicable.

****

Each motor shall be a [single speed] [two speed], totally enclosed, insulation Class B, NEMA Design B, continuous-rated, and conforming to NEMA MG 1. Fan motors shall have [open] [dripproof] [totally enclosed] [explosion proof] enclosures and be located outside the discharge airstream. Motors shall be mounted according to manufacturer's recommendations. Two-speed motors shall have a single winding with variable torque characteristics.

2.9.14 Stairways and Ladders

Provide stairs, 60-degree ship ladders or straight-rung ladders of standard design, starting at [ground] [roof] level and extending as high as required to gain access to fan decks and water distribution systems. Stairways and ladders shall be hot-dip, zinc-coated steel. Ladders higher than 3.66 meters (12 feet) 12 feet shall have a safety cage.

2.9.15 Handrailings

Steel handrailings shall be not less than 1067 mm (42 inches) 42 inches high around the exterior of each working surface that is 3.66 m (12 feet) 12 feet or more above the ground, roof, or other supporting construction. Railings shall be not smaller than 32 mm (1-1/4 inch) 1-1/4 inch zinc-coated steel pipe with standard zinc-coated steel railing.

2.9.16 Access Doors

Each tower shall be provided with access doors at grade level to provide entry to the interior for service maintenance without removal of the fill. Doors shall be provided with doors on each endwall of each cooling tower cell. Frame and brace access doors to prevent damage when opening and closing. Doors shall be located adjacent to float controls.

2.10 WATER TREATMENT SYSTEMS

When water treatment is specified, the use of chemical-treatment products containing hexavalent chromium (Cr) is prohibited.

2.10.1 Water Analysis

****

NOTE: A water analysis may be available from the user. If an analysis is not available, an analysis will be performed during the design, and appropriate data will be entered.

****

Conditions of make-up water to be supplied to the condenser and chilled water systems are as follows:

Date of Sample	[_____]	
Temperature	[_____]	degrees C.
Silica (SiO 2)	[_____]	ppm (mg/1)
Insoluble	[_____]	ppm (mg/1)
Iron and Aluminum Oxides	[_____]	ppm (mg/1)

Calcium (Ca)	[_____]	ppm (mg/1)
Magnesium (Mg)	[_____]	ppm (mg/1)
Sodium and Potassium (Na and K)	[_____]	ppm (mg/1)
Carbonate (HCO 3)	[_____]	ppm (mg/1)
Sulfate (SO 4)	[_____]	ppm (mg/1)
Chloride (Cl)	[_____]	ppm (mg/1)
Nitrate (NO 3)	[_____]	ppm (mg/1)
Turbidity	[_____]	unit
pH	[_____]	
Residual Chlorine	[_____]	ppm (mg/1)
Total Alkalinity	[_____]	epm (meq/1)
Non-Carbonate Hardness	[_____]	epm (meq/1)
Total Hardness	[_____]	epm (meq/1)
Dissolved Solids	[_____]	ppm (mg/1)
Fluorine	[_____]	ppm (mg/1)
Conductivity	[_____]	micrmho/cm

Date of Sample	[_____]	
Temperature	[_____]	degrees F.
Silica (SiO 2)	[_____]	ppm (mg/1)
Insoluble	[_____]	ppm (mg/1)
Iron and Aluminum Oxides	[_____]	ppm (mg/1)
Calcium (Ca)	[_____]	ppm (mg/1)
Magnesium (Mg)	[_____]	ppm (mg/1)
Sodium and Potassium (Na and K)	[_____]	ppm (mg/1)
Carbonate (HCO 3)	[_____]	ppm (mg/1)
Sulfate (SO 4)	[_____]	ppm (mg/1)
Chloride (Cl)	[_____]	ppm (mg/1)
Nitrate (NO 3)	[_____]	ppm (mg/1)
Turbidity	[_____]	unit
pH	[_____]	
Residual Chlorine	[_____]	ppm (mg/1)
Total Alkalinity	[_____]	epm (meq/1)
Non-Carbonate Hardness	[_____]	epm (meq/1)
Total Hardness	[_____]	epm (meq/1)
Dissolved Solids	[_____]	ppm (mg/1)
Fluorine	[_____]	ppm (mg/1)
Conductivity	[_____]	micrmho/cm

2.10.2 Chilled and Condenser Water

Water to be used in the chilled and condenser water systems shall be treated to maintain the conditions recommended by this specification as well as the recommendations from the manufacturers of the condenser and evaporator coils. Chemicals shall meet all required federal, state, and local environmental regulations for the treatment of evaporator coils and direct discharge to the sanitary sewer.

2.10.3 Glycol Solution

****

NOTE: If freeze protection for chilled water is not required, this paragraph should be deleted. When a glycol system is used, the size of the HVAC systems

should be corrected due to changes in specific heat and viscosity. ASHRAE's "HVAC systems and Equipment Handbook" should be consulted for the appropriate calculation procedures. Ethylene glycol should be used for HVAC systems. However, if the heat transfer media has the possibility of mixing with a potable water system, propylene glycol should be used. The required concentration should be entered based upon the anticipated ambient or operating temperature.

****

A [_____] percent concentration by volume of industrial grade [ethylene] [propylene] glycol shall be provided for the system. The glycol shall be tested in accordance with ASTM D 1384 with less than 0.013 mm (0.5 mils) 0.5 mils penetration per year for all system metals. The glycol shall contain corrosion inhibitors. Silicate based inhibitors shall not be used. The solution shall be compatible with pump seals, other elements of the system, and water treatment chemicals used within the system.

2.10.4 Water Treatment Services

****

NOTE: The services of a water treatment company to treat a chilled water system should only be required if the makeup water available is of very poor quality.

****

The services of a company regularly engaged in the treatment of [condenser] [condenser and chilled] water systems shall be used to determine the correct chemicals required, the concentrations required, and the water treatment equipment sizes and flow rates required. The company shall maintain the chemical treatment and provide all chemicals required for the [condenser] [condenser and chilled] water systems for a period of 1 year from the date of occupancy. The chemical treatment and services provided over the 1 year period shall meet the requirements of this specification as well as the recommendations from the manufacturers of the condenser and evaporator coils. Acid treatment and proprietary chemicals shall not be used.

2.10.5 Chilled Water System

****

NOTE: For dual temperature systems (chilled and heated water), coordinate the compatibility of the separate water treatment systems.

****

A shot feeder shall be provided on the chilled water piping as indicated. Size and capacity of feeder shall be based on local requirements and water analysis. The feeder shall be furnished with an air vent, gauge glass, funnel, valves, fittings, and piping.

2.10.6 Condenser Water

****

NOTE: Cooling towers with a capacity of greater than 176 kW (50 tons) will be provided with automatic chemical feed and blow down systems. Smaller towers will be provided with continuously activated systems. Indicate the location of the entire water treatment system. Delete all the information under this paragraph if a cooling tower is not used in the system.

****

The water treatment system shall be capable of [automatically] [continuously] feeding chemicals and bleeding the system to prevent corrosion, scale, and biological formations. [Automatic chemical feed systems shall automatically feed chemicals into the condenser water based on varying system conditions.] [Continuous chemical feed systems shall continuously feed chemicals into the condenser water at a constant rate. The system shall be initially set manually based on the water analysis of the make-up water.]

2.10.6.1 Chemical Feed Pump

One pump shall be provided for each chemical feed tank. The chemical feed pumps shall be positive displacement diaphragm type. The flow rate of the pumps shall be adjustable from 0 to 100 percent while in operation. The discharge pressure of pumps shall not be less than 1.5 times the line pressure at the point of connection. The pumps shall be provided with a pressure relief valve and a check valve mounted in the pump discharge.

2.10.6.2 Tanks

Two chemical tanks shall be provided. The tanks shall be constructed of [high density polyethylene] [stainless steel] with a hinged cover. The tanks shall have sufficient capacity to require recharging only once per 7 days during normal operation. A level indicating device shall be included with each tank. An electric agitator shall be provided for each tank.

2.10.6.3 Injection Assembly

An injection assembly shall be provided at each chemical injection point along the condenser water piping as indicated. The injection assemblies shall be constructed of stainless steel. The discharge of the assemblies shall extend to the centerline of the condenser water piping. Each assembly shall include a shutoff valve and check valve at the point of entrance into the condenser water line.

2.10.6.4 Water Meter

Water meters shall be provided with an electric contacting register and remote accumulative counter. The meter shall be installed within the make-up water line, as indicated.

2.10.6.5 Timers

Timers shall be of the automatic reset, adjustable type, and electrically operated. The timers shall be suitable for a 120 volt current. The timers shall be located within the water treatment control panel.

2.10.6.6 Water Treatment Control Panel

****

NOTE: The MAN-OFF-AUTO switch should be deleted for continuously fed systems. In areas where a panel could come in contact with the water treatment chemical, choose the stainless steel construction.

****

The control panel shall be a NEMA 12 enclosure suitable for surface mounting. The panel shall be constructed of [stainless steel] [steel] with a hinged door and lock. The panel shall contain a laminated plastic nameplate identifying each of the following functions:

(1) Main power switch and indicating light
(2) MAN-OFF-AUTO selector switch
(3) Indicating lamp for bleed-off valve
(4) Indicating lamp for each chemical feed pump
(5) Set point reading for each timer

2.10.6.7 Chemical Piping

The piping and fittings shall be constructed of [schedule 80 PVC] [stainless steel] suitable for the water treatment chemicals.

2.10.6.8 Sequence of Operation

****

NOTE: Choose the first set of brackets for automatic chemical feed systems. Choose the second set of brackets for continuous chemical feed systems.

****

[The chemicals shall be added based upon sensing the make-up water flow rate and activating appropriate timers. A separate timer shall be provided for each chemical. The blow down shall be controlled based upon the make-up water flow rate and a separate timer.] [The system shall contain an adjustable valve for continuous blow down. The flow rate from the appropriate chemical tanks shall be manually set at the metering pump for continuous chemical feed.] The injection of the chemical required for biological control shall be controlled by a timer which can be manually set for proper chemical feed. All timer set points, blow down rates, and chemical pump flow rates shall be determined and set by the water treatment company.

2.10.6.9 Test Kits

One test kit of each type required to determine the water quality as

outlined within the operation and maintenance manuals shall be provided.

2.10.6.10 Bleed Line

****
NOTE: Delete the following paragraph on bleed lines if an automatic chemical system is chosen.
****

A bleed line with a flow valve of the needle-valve type sized for the flow requirement or fixed orifice shall be provided in the pump return to the tower. The bleed line shall be extended to the nearest drain for continuous discharge.

2.11 PIPING COMPONENTS

2.11.1 Water Piping and Fittings

2.11.1.1 Steel Pipe

Steel pipe shall conform to ASTM A 53, Schedule 40, Type E or S, Grades A or B. Type F pipe shall not be used.

2.11.1.2 Steel Pipe Joints and Fittings

Joints and fittings shall be welded, flanged, threaded, or grooved as indicated. If not otherwise indicated, piping 25 mm (1 inch) 1 inch and smaller shall be threaded; piping larger than 25 mm (1 inch) 1 inch and smaller than 80 mm (3 inches) 3 inches shall be either threaded, grooved, or welded; and piping 80 mm (3 inches) 3 inches and larger shall be grooved, welded, or flanged. Rigid grooved mechanical joints and fittings may only be used in serviceable aboveground locations where the temperature of the circulating medium does not exceed 110 degrees C.230 degrees F. Flexible grooved joints shall be used only as a flexible connector with grooved pipe system. Unless otherwise specified, grooved piping components shall meet the corresponding criteria specified for the similar welded, flanged, or threaded component specified herein. The manufacturer of each fitting shall be permanently identified on the body of the fitting in accordance with MSS SP-25.

a. Welded Joints and Fittings: Welded fittings shall conform to ASTM A 234/A 234M, and identified with the appropriate grade and marking symbol. Butt-welding fittings shall conform to ASME B16.9. Socket-welding and threaded fittings shall conform to ASME B16.11.

b. Flanged Joints and Fittings: Flanges shall conform to ASTM A 181/A181M and ASME B16.5 Class 150. Gaskets shall be nonasbestos compressed material in accordance with ASME B16.21, 1.59 mm (1/16 inch) 1/16 inch thickness, full face or self-centering flat ring type. This gaskets shall contain aramid fibers bonded with styrene butadeine rubber (SBR) or nitrile butadeine rubber (NBR). Bolts, nuts, and bolt patterns shall conform to ASME B16.5. Bolts shall be high or intermediate strength material conforming to ASTM A 193/A 193M.

c. Threaded Joints and Fittings: Threads shall conform to ASME B1.20.1. Pipe nipples shall conform to ASTM A 733, type and material to match adjacent piping. Unions shall conform to ASME B16.39, type as required to match adjacent piping.

d. Dielectric Unions and Flanges: Dielectric unions shall have the tensile strength and dimensional requirements specified. Unions shall have metal connections on both ends threaded to match adjacent piping. Metal parts of dielectric unions shall be separated with a nylon insulator to prevent current flow between dissimilar metals. Unions shall be suitable for the required operating pressures and temperatures. Dielectric flanges shall provide the same pressure ratings as standard flanges and provide complete electrical isolation.

e. Grooved Mechanical Joints and Fittings: Joints and fittings shall be designed for not less than 862 kPa (125 psig) 125 psig service and shall be the product of the same manufacturer. Fitting and coupling houses shall be malleable iron conforming to ASTM A 47, ASTM A 47M, Grade 32510; ductile iron conforming to ASTM A 536, Grade 65-45-12; or steel conforming ASTM A 106, Grade B or ASTM A 53. Gaskets shall be molded synthetic rubber with central cavity, pressure responsive configuration and shall conform to ASTM D 2000 Grade No. 2CA615A15B44F17Z for circulating medium up to 110 degrees C (230 degrees F) 230 degrees F or Grade No. M3BA610A15B44Z for circulating medium up to 93 degrees C (200 degrees F).200 degrees F. Grooved joints shall conform to AWWA C606. Coupling nuts and bolts shall be steel and shall conform to ASTM A 183.

2.11.1.3 Copper Tube

Copper tubing for water service shall conform to ASTM B 88,ASTM B 88M, Type K or L.

2.11.1.4 Copper Tube Joints and Fittings

Wrought copper and bronze solder-joint pressure fittings shall conform to ASME B16.22 and ASTM B 75MASTM B 75. Cast copper alloy solder-joint pressure fittings shall conform to ASME B16.18. Cast copper alloy fittings for flared copper tube shall conform to ASME B16.26 and ASTM B 62. Brass or bronze adapters for brazed tubing may be used for connecting tubing to flanges and to threaded ends of valves and equipment. Extracted brazed tee joints produced with an acceptable tool and installed as recommended by the manufacturer may be used.

2.11.2 Water Piping Valves and Accessories

Valves shall be rated for Class 125 and shall be suitable for operating temperature of 120 degrees C (250 degrees F).250 degrees F. Valves shall be suitable for the working pressure of the pipe in which installed. Valves shall meet the material, fabrication and operating requirements of ASME B31.1. Chain operators shall be provided for valves located 3 m 10

feet or higher above the floor. Valves in sizes larger than 25 mm (1 inch) 1 inch and used on steel pipe systems, may be provided with rigid grooved mechanical joint ends. Such grooved end valves shall be subject to the same requirements as rigid grooved mechanical joints and fittings and, shall be provided by the same manufacturer as the grooved pipe joint and fitting system.

2.11.2.1 Gate Valves

Gate valves 65 mm (2-1/2 inches) 2-1/2 inches and smaller shall conform to MSS SP-80 and shall be bronze with rising stem and threaded, soldered, or flanged ends. Gate valves 80 mm (3 inches) 3 inches and larger shall conform to MSS SP-70, Type I, II, Class 125, Design OF and shall be cast iron with bronze trim, outside screw and yoke, and flanged or threaded ends.

2.11.2.2 Globe and Angle Valves

Globe and angle valves 65 mm (2-1/2 inches) 2-1/2 inches and smaller shall conform to MSS SP-80 and shall be bronze with threaded, soldered, or flanged ends. Globe and angle valves 80 mm (3 inches) 3 inches and larger shall conform to MSS SP-85 and shall be cast iron with bronze trim and flanged or threaded ends.

2.11.2.3 Check Valves

Check valves 65 mm (2-1/2 inches) 2-1/2 inches and smaller shall conform to MSS SP-80 and shall be bronze with threaded, soldered, or flanged ends. Check valves 80 mm (3 inches) 3 inches and larger shall conform to MSS SP-71, Type I, II, III, or IV, Class 125 or 150 and shall be cast iron with bronze trim and flanged or threaded ends.

2.11.2.4 Butterfly Valves

Butterfly valves shall be in accordance with MSS SP-67, Type 1 and shall be 2 flange or lug wafer type, and shall be bubble tight at [1,000 kPa (150 psig)] [1,700 kPa (250 psig)].[150] [250] psig. Valve bodies shall be cast iron, malleable iron, or steel. Valves smaller than 200 mm (8 inches) 8 inches shall have throttling handles with a minimum of seven locking positions. Valves 200 mm (8 inches) 8 inches and larger shall have totally enclosed manual gear operators with adjustable balance return stops and position indicators. Valves in insulated lines shall have extended neck to accommodate insulation thickness.

2.11.2.5 Plug Valves

Plug valves 50 mm (2 inches) 2 inches and larger shall conform to MSS SP-78, have flanged or threaded ends, and have cast iron bodies with bronze trim. Valves 50 mm (2 inches) 2 inches and smaller shall be bronze with NPT connections for black steel pipe and brazed connections for copper tubing. Valves shall be lubricated, non-lubricated, or tetrafluoroethylene resin-coated type. Valves shall be resilient, double seated, trunnion mounted with tapered lift plug capable of 2-way shutoff. Valves shall operate from fully open to fully closed by rotation of the handwheel to lift and turn the plug. Valves shall a weatherproof operators with

mechanical position indicators. Valves 200 mm (8 inches) 8 inches or larger shall be provided with manual gear operators with position indicators.

2.11.2.6 Ball Valves

Ball valves 15 mm (1/2 inch) 1/2 inch and larger shall conform to MSS SP-72 or MSS SP-110 and shall be ductile iron or bronze with threaded, soldered, or flanged ends. Valves 200 mm (8 inches) 8 inches or larger shall be provided with manual gear operators with position indicators.

2.11.2.7 Calibrated Balancing Valves

****

NOTE: Plug and ball valves defined above will be used as manual balancing valves and will be indicated on the drawings. A supplemental flow measuring scheme or device must be used to measure flow with a manual balancing valve. A calibrated balancing valve incorporates a flow measuring element and can be used in place of a manual balancing valve and a flow measuring device. Delete the last sentence of this paragraph if inapplicable.

****

Each valve shall be calibrated so that flow can be determined when the temperature and pressure differential across valve is known. Valves shall have an integral pointer which registers the degree of valve opening. Each valve shall be constructed with internal seals to prevent leakage and shall be supplied with preformed insulation. Valves Cv rating shall be as indicated. Valve bodies shall be provided with tapped openings and pipe extensions with positive shutoff valves outside of pipe insulation. The pipe extensions shall be provided with quick connecting hose fittings for a portable meter to measure the pressure differential. One portable differential meter, suitable for the operating pressure specified, shall be provided. The meter shall be complete with hoses, vent, integral metering connections, and carrying case as recommended by the valve manufacturer. In lieu of the balancing valve with integral metering connections, a ball valve or plug valve with a separately installed orifice plate or venturi tube may be used for balancing.

2.11.2.8 Automatic Flow Control Valves

****

NOTE: An automatic flow control valve offers complete flow control in many applications; however, the flow control range is dependent on inlet pressure being within a given range, the flow selection is limited, and, in some cases it may require pump power slightly more than alternative balancing means. In any facility where typical load imbalances cannot be tolerated and where automatic control is needed to ensure constant hydronic flow, the design will incorporated automatic flow control

valves. The location and capacity of the automatic control valves will be shown on the drawings.
****

Valves shall automatically maintain a constant flow as indicated. Valves shall modulate by sensing the pressure differential across the valve body. Valves shall be selected for the flow required and provided with a permanent nameplate or tag carrying a permanent record of the factory-determined flow rate and flow control pressure levels. Valves shall control the flow within 5 percent of the tag rating. Valve materials shall be the same as specified for the ball or plug valves. Valve Cv rating shall be as indicated. Valve operators shall be the [electric] [or] [pneumatic] type as indicated. Valves shall be capable of positive shutoff against the system pump head, valve bodies shall be provided with tapped openings and pipe extensions with shutoff valves outside of pipe insulation. The pipe extensions shall be provided with quick connecting hose fittings and differential meter, suitable for the operating pressure specified. The meter shall be complete with hoses, vent, integral metering connections, and carrying case as recommended by the valve manufacturer.

2.11.2.9 Air Vents

****
NOTE: Air vents will be shown on drawings; distinguish between manual and automatic air vents.
****

Manual air vents shall be brass or bronze valves or cocks suitable for 862 kpa (125 psig) 125 psig service, and furnished with threaded plugs or caps. Automatic air vents shall be float type, cast iron, stainless steel, or forged steel construction, suitable for 862 kpa (125 psig) 125 psig service.

2.11.2.10 Strainers

****
NOTE: Reference ASTM F 1199 when the operating conditions are at 1034 kPa (150 psig) and 66 degrees C (150 degrees F) or less; otherwise reference ASTM F 1200.
****

Strainers shall be in accordance with [ASTM F 1199] [ASTM F 1200], except as modified herein. Strainer shall be the cleanable, basket or "Y" type, the same size as the pipeline. The strainer bodies shall be fabricated of cast iron with bottoms drilled, and tapped. The bodies shall have arrows clearly cast on the sides indicating the direction of flow. Each strainer shall be equipped with removable cover and sediment screen. The screen shall be made of minimum 0.8 mm (22 gauge) 22 gauge [brass sheet,] [monel,] [corrosion-resistant steel,] with small perforations numbering not less than 60 per square centimeter (400 per square inch) 400 per square inch to provide a net free area through the basket of at least 3.30 times that of the entering pipe. The flow shall be into the screen and out through the perforations.

2.11.2.11 Combination Strainer and Suction Diffuser

A combination strainer and suction diffuser, consisting of an angle type body with removable strainer basket and straightening vanes, a suction pipe support, and a blowdown outlet, shall be provided on pump suction. The combination strainer and suction diffuser shall be in accordance with [ASTM F 1199] [ASTM F 1200], except as modified herein.

2.11.2.12 Pump Discharge Valves

****

NOTE: Pump discharge valves can be used as an alternative to a gate valve, a check valve, and a balancing valve on the discharge side of a pump.

****

Pump discharge valves shall be installed where indicated and shall perform the functions of a nonslam check valve, a manual balancing valve, and a shutoff. Valves shall be of cast iron or ductile iron construction with bronze and/or stainless steel accessories. Valves shall have an integral pointer which registers the degree of valve opening. Flow through the valve shall be manually adjustable from bubble tight shutoff to full flow. Valves smaller than 50 mm (2 inches) 2 inches shall have NPT connections. Valves 50 mm (2 inches) 2 inches and larger shall have flanged or grooved end connections. The valve design shall allow the back seat for the stem to be replaced in the field under full line pressure. Valve Cv rating shall be as indicated.

2.11.2.13 Flexible Pipe Connectors

Flexible pipe connectors shall be designed for 862 kpa (125 psig) 125 psig or 1034 kPa (150 psig) 150 psig service as appropriate for the static head plus the system head, and [120] [110] degrees C ([250] [230] degrees F), [250] [230] degrees F, for grooved end flexible connectors. The flexible section shall be constructed of rubber, tetrafluoroethylene resin, or corrosion-resisting steel, bronze, monel, or galvanized steel. The flexible section shall be suitable for intended service with end connections to match adjacent piping. Flanged assemblies shall be equipped with limit bolts to restrict maximum travel to the manufacturer's standard limits. Unless otherwise indicated, the length of the flexible connectors shall be as recommended by the manufacturer for the service intended. Internal sleeves or liners, compatible with circulating medium, shall be provided when recommended by the manufacturer. Covers to protect the bellows shall be provided where indicated.

2.11.2.14 Pressure Gauges

Gauges shall conform to ASME B40.1 and shall be provided with throttling type needle valve or a pulsation dampener and shut-off valve. Gauge shall be a minimum of 85 mm 3-1/2 inches in diameter with a range from 0 kPa (0 psig) 0 psig to approximately 1.5 times the maximum system working pressure.

2.11.2.15 Thermometers

Thermometers shall have brass, malleable iron, or aluminum alloy case and frame, clear protective face, permanently stabilized glass tube with indicating-fluid column, white face, black numbers, and a 225 mm (9 inch) 9 inch scale. Thermometers shall have rigid stems with straight, angular, or inclined pattern.

2.11.2.16 Pipe Nipples

Pipe nipples shall be in accordance with ASTM A 733 and be of material to match adjacent piping.

2.11.2.17 Pipe Unions

Pipe unions shall be in accordance with ASME B16.39 and be of material to match adjacent piping.

2.11.2.18 Solder

Solder for water piping shall be in accordance with ASTM B 32, alloy grade 50B. Solder flux shall be liquid or paste form, non-corrosive and conform to ASTM B 813.

2.11.3 Expansion Joints

****

NOTE: Expansion loops, offsets, and bends will be used where possible instead of expansion joints. All expansion provisions, including necessary details, will be shown on the drawings. Expansion joints should be located in serviceable areas. Expansion joints may only be installed on water piping.

****

2.11.3.1 Slip-Tube Joints

Expansion joints shall provide for either single or double slip of the connected pipes, as required or indicated, and for not less than the traverse indicated. The joints shall be designed for working temperature and pressure suitable for the application, but not less than 1034 kPa (150 psig), 150 psig, and shall be in accordance with applicable requirements of EJMA Stds and ASME B31.1. End connections shall be flanged or beveled for welding as indicated. Joints shall be provided with an anchor base where required or indicated. Where adjoining pipe is carbon steel, the sliding slip shall be seamless steel plated with a minimum of 0.12 mm 5 mils of hard chrome in accordance with ASTM B 650. All joint components shall be suitable for the intended service. Initial settings shall be made in accordance with the manufacturer's recommendations to compensate for ambient temperature at time of installation. Pipe alignment guides shall be installed as recommended by the joint manufacturer. Pipe alignment guides shall in no case be more than 1.5 m 5 feet from expansion joints except for pipe 100 mm (4 inches) 4 inches or smaller. Pipe alignment guides on pipe 100 mm (4 inches) 4 inches or smaller shall be installed not more than 600 mm 2 feet from expansion joints. Service outlets shall be

provided where indicated.

2.11.3.2 Flexible Ball Joints

****
NOTE: The ball joint only moves in an angular offset or rotation mode. The configuration of the ball joint link will require a 2 or 3 ball joint offset to absorb axial and/or lateral movement.
****

Flexible ball joints shall be constructed of alloys as appropriate for the service intended. Where so indicated, the ball joint shall be designed for packing injection under full line pressure to contain leakage. The joint ends shall be threaded to 50 mm (2 inches) 2 inches only, grooved, flanged, or beveled for welding as indicated or required and shall be capable of absorbing a minimum of 15 degree angular flex and 360 degree rotation. Ball and sockets shall be suitable for the intended service. The exterior spherical surface of carbon steel balls shall be plated with minimum 0.12 mm 5 mils of hard chrome in accordance with EJMA Stds and ASME B31.1 where applicable. Where required, flanges shall conform to ASME B16.5.

2.11.3.3 Bellows Type Joints

Bellows type joints shall be flexible, guided expansion joints. The expansion element shall be stabilized corrosion resistant steel. Bellows type expansion joints shall conform to the applicable requirements of EJMA Stds and ASME B31.1 with internal sleeves. Guiding of piping on both sides of expansion joint shall be in accordance with the published recommendations of the manufacturer of the expansion joint. The joints shall be designed for the working temperature and pressure suitable for the application but not less than 1034 kPa (150 psig).150 psig.

2.11.4 Refrigerant Piping and Fittings

Refrigerant piping, valves, fittings, and accessories shall conform to the requirements of ASHRAE 15 and ASME B31.5, except as specified.

2.11.4.1 Steel Pipe

Steel pipe for refrigerant service shall conform to ASTM A 53, Schedule 40, Type E or S, Grades A or B. Type F pipe shall not be used.

2.11.4.2 Steel Pipe Joints and Fittings

Joints and fittings shall be steel butt-welding, socket-welding, or malleable iron threaded type. Pipe shall be welded except that joints on lines 50 mm (2 inches) 2 inches and smaller may be threaded. Threads shall be tapered type conforming to ASME B1.20.1. The malleable iron threaded type fitting shall be of a weight corresponding to adjacent pipe. Flanges and flange faces of fittings shall be tongue-and-groove type with gaskets suitable for the refrigerant used; size 25 mm (1 inch) 1 inch and smaller shall be oval, two-bolt type; size above 25 mm (1 inch), 1 inch, up to and including 100 mm (4 inches), 4 inches, shall be square four-bolt type; and

sizes over 100 mm (4 inches) 4 inches shall be round.

2.11.4.3 Steel Tubing

Steel tubing for refrigeration service shall be in accordance with ASTM A 334/A 334M, Grade 1. Tubing with a nominal diameter of 10 mm (3/8 inch) 3/8 inch or 15 mm (1/2 inch) 1/2 inch shall have a wall thickness of 1.24 mm (0.049 inches).0.049 inches. Tubing with a nominal diameter of 20 mm (3/4 inch) 3/4 inch through 50 mm (2 inches) 2 inches shall have a wall thickness of 1.65 mm (0.065 inches).0.065 inches. Tubing with a nominal diameter of 65 mm (2-1/2 inches) 2-1/2 inches through 100 mm (4 inches) 4 inches shall have a wall thickness of 2.41 mm (0.095 inches).0.095 inches. Steel tubing shall be cold-rolled, electric-forged, welded-steel. One end of the tubing shall be provided with a socket. Steel tubing shall be cleaned, dehydrated, and capped.

2.11.4.4 Steel Tubing Joints and Fittings

Joints and fittings shall be socket type provided by the steel tubing manufacturer.

2.11.4.5 Copper Tubing

Copper tubing shall conform to ASTM B 280 annealed or hard drawn as required. Copper tubing shall be soft annealed where bending is required and hard drawn where no bending is required. Soft annealed copper tubing shall not be used in sizes larger than 35 mm (1-3/8 inches).1-3/8 inches. Joints shall be brazed except that joints on lines 22 mm (7/8 inch) 7/8 inch and smaller may be flared.

2.11.4.6 Copper Tube Joints and Fittings

Copper tube joints and fittings shall be flare joint type with short-shank flare, or solder-joint pressure type. Joints and fittings for brazed joint shall be wrought-copper or forged-brass sweat fittings. Cast sweat-type joints and fittings shall not be allowed for brazed joints.

2.11.5 Refrigerant Piping, Valves, and Accessories

Valves shall be pressure and temperature rates for contained refrigerant service and shall comply with ASME B31.5. Metals of constructions shall be ferrous or copper based. Atmosphere exposed valve stems shall be stainless steel or corrosion resistant metal plated carbon steel. Valve body connections shall not be used, except in pilot pressure or gauge lines where maintenance disassembly is required and welded flanges cannot be used. Valves shall be suitable for or fitted with extended copper ends for brazing in-place without disassembly. Ferrous body valves shall be fitted with factory fabricated and brazed copper transitions. To minimize system pressure drops, where practicable, globe valves shall be angle body type, and straight line valves shall be full port ball type. Control valve inlets shall be fitted with integral or adapted strainer or filter where recommended or required by the manufacturer. Valves shall be cleaned and sealed moisture-tight.

2.11.5.1 Refrigerant-Stop Valves

Valves, in sizes through 15 mm (5/8 inch), 5/8 inch, shall be handwheel operated, straight or angle, packless diaphragm globe type with back-seating stem, brazed ends, except where SAE flare or retained seal cap connections are required. In sizes over 15 mm (5/8 inch), 5/8 inch, valves shall be globe or angle type, wrench operated with ground-finish stems, or ball valves, packed especially for refrigerant service, back seated, and provided with seal caps. Refrigerant isolation and shut-off valves shall have retained or captive spindles and facilities for tightening or replacement of the gland packing under line pressure as applicable. Stop valves hall have back-seating plated steel stem, bolted bonnet in sizes 25 mm (1-1/8 inches) 1-1/8 inches OD and larger, integral or flanged transition brazed socket. Valves in sizes through 65 mm (2-1/2 inches) 2-1/2 inches shall be end-entry body assembly, full-port, floating ball type, with equalizing orifice fitted chrome plated ball, seats and seals of tetrafluoroethylene, chrome plated or stainless steel stem, and seal cap. In sizes 100 mm (4 inch) 4 inch IPS and larger, and in smaller sizes where carbon steel piping is used, valve bodies shall be tongue and groove flanged and complete with mating flange, gaskets and bolting for socket or butt-welded connection. Purge, charge and receiver valves shall be of manufacturer's standard configuration.

2.11.5.2 Check Valves

Valve shall be designed for service application, spring-loaded type where required, with resilient seat and with flanged body in sizes 15 mm (1/2 inch) 1/2 inch and larger. Valve shall provide positive shutoff at [10] [14] [20] kPa ([-1/2] [2] [3] psi) [1-1/2] [2] [3] psi differential pressure.

2.11.5.3 Liquid Solenoid Valves

Valves shall comply with ARI 760 and be suitable for continuous duty with applied voltages 15 percent under and 5 percent over nominal rated voltage at maximum and minimum encountered pressure and temperature service conditions. Valves shall be direct-acting or pilot-operating type, packless, except that packed stem, seal capped, manual lifting provisions shall be furnished. Solenoid coils shall be moisture-proof, UL approved, totally encapsulated or encapsulated and metal jacketed as required. Valves shall have safe working pressure of 2760 kPa (400 psi) 400 psi and a maximum operating pressure differential of at least 1375 kPa (200 psi) 200 psi at 85 percent rated voltage. Valves shall have an operating pressure differential suitable for the refrigerant used.

2.11.5.4 Expansion Valves

Expansion valves shall conform to requirements of ARI 750. Valve shall be of the diaphragm and spring type with internal or external equalizers, and bulb and capillary tubing. Valve shall be provided with an external superheat adjustment along with a seal cap. Internal equalizers may be utilized where flowing refrigerant pressure drop between outlet of the valve and inlet to the evaporator coil is negligible and pressure drop across the evaporator is less than the pressure difference corresponding to

1 degrees C (2 degrees F) 2 degrees F of saturated suction temperature at evaporator conditions. Bulb charge shall be determined by the manufacturer for the application and such that liquid will remain in the bulb at all operating conditions. Gas limited liquid charged valves and other valve devices for limiting evaporator pressure shall not be used without a distributor or discharge tube or effective means to prevent loss of control when bulb becomes warmer than valve body. Pilot-operated valves shall have a characterized plug to provide required modulating control. A de-energized solenoid valve may be used in the pilot line to close the main valve in lieu of a solenoid valve in the main liquid line. An isolatable pressure gauge shall be provided in the pilot line, at the main valve. Automatic pressure reducing or constant pressure regulating expansion valves may be used only where indicted or for constant evaporator loads.

2.11.5.5 Safety Relief Valves

Valve shall be two-way type. Single type valves shall be used only where indicated. Valve shall bear the ASME code symbol. Valve capacity shall be certified by the National Board of Boiler and Pressure Vessel Inspectors. Valve shall be of an automatically reseating design after activation.

2.11.5.6 Evaporator Pressure Regulators, Direct-Acting

Valve shall include a diaphragm/spring assembly, external pressure adjustment with seal cap, and pressure gauge port. Valve shall maintain a constant inlet pressure by balancing inlet pressure on diaphragm against an adjustable spring load. Pressure drop at system design load shall not exceed the pressure difference corresponding to a 1 degrees C 2 degrees F change in saturated refrigerant temperature at evaporator operating suction temperature. Spring shall be selected for indicated maximum allowable suction pressure range.

2.11.5.7 Refrigerant Access Valves

Refrigerant access valves and hose connections shall be in accordance with ARI 720.

2.11.5.8 Filter Driers

Driers shall conform to ARI 710. Sizes 15 mm (5/8 inch) 5/8 inch and larger shall be the full flow, replaceable core type. Sizes 15 mm (1/2 inch) 1/2 inch and smaller shall be the sealed type. Cores shall be of suitable desiccant that will not plug, cake, dust, channel, or break down, and shall remove water, acid, and foreign material from the refrigerant. Filter driers shall be constructed so that none of the desiccant will pass into the refrigerant lines. Minimum bursting pressure shall be 10.3 MPa (1.500 psi).1,500 psi.

2.11.5.9 Sight Glass and Liquid Level Indicator

a. Assembly and Components: Assembly shall be pressure- and temperature-rated and constructed of materials suitable for the service. Glass shall be borosilicate type. Ferrous components subject to condensation shall be electro-galvanized.

b. Gauge Glass: Gauge glass shall include top and bottom isolation valves fitted with automatic checks, and packing followers; red-line or green-line gauge glass; elastomer or polymer packing to suit the service; and gauge glass guard.

c. Bull's-Eye and Inline Sight Glass Reflex Lens: Bull's-eye and inline sight glass reflex lens shall be provided for dead-end liquid service. For pipe line mounting, two plain lenses in one body suitable for backlighted viewing shall be provided.

d. Moisture Indicator: Indicator shall be a self-reversible action, moisture reactive, color changing media. Indicator shall be furnished with full-color-printing tag containing color, moisture and temperature criteria. Unless otherwise indicated, the moisture indicator shall be an integral part of each corresponding sight glass.

2.11.5.10 Vibration Dampeners

Dampeners shall be of the all-metallic bellows and woven-wire type.

2.11.5.11 Flexible Pipe Connectors

Connector shall be pressure and temperature rated for the service in accordance with ASHRAE 15 and ASME B31.5. Connector shall be a composite of interior corrugated phosphor bronze or Type 300 Series stainless steel, as required for fluid service, with exterior reinforcement of bronze, stainless steel or monel wire braid. Assembly shall be constructed with a safety factor of not less than 4 at 150 degrees C (300 degrees F).300 degrees F. Unless otherwise indicated, the length of a flexible connector shall be as recommended by the manufacturer for the service intended.

2.11.5.12 Strainers

Strainers used in refrigerant service shall have brass or cast iron body, Y-or angle-pattern, cleanable, not less than 60-mesh noncorroding screen of an area to provide net free area not less than ten times the pipe diameter with pressure rating compatible with the refrigerant service. Screens shall be stainless steel or monel and reinforced spring-loaded where necessary for bypass-proof construction.

2.11.5.13 Brazing Materials

Brazing materials for refrigerant piping shall be in accordance with AWS A5.8, Classification BCuP-5.

2.11.6 Escutcheons

Escutcheons shall be chromium-plated iron or chromium-plated brass, either one piece or split pattern, held in place by internal spring tension or set screws.

2.11.7 Pipe Hangers, Inserts, and Supports

Pipe hangers, inserts, and supports shall conform to MSS SP-58 and MSS SP-69.

2.12 FABRICATION

2.12.1 Factory Coating

****
NOTE: Adequate protection will be specified and unit will be tested in a salt spray fog test. A 125 hour test will be specified in a noncorrosive environment and a 500 hour test will be specified in a corrosive environment.
****

Unless otherwise specified, equipment and component items, when fabricated from ferrous metal, shall be factory finished with the manufacturer's standard finish, except that items located outside of buildings shall have weather resistant finishes that will withstand 500 hours exposure to the salt spray test specified in ASTM B 117 using a 5 percent sodium chloride solution. Immediately after completion of the test, the specimen shall show no signs of blistering, wrinkling, cracking, or loss of adhesion and no sign of rust creepage beyond 3 mm 1/8 inch on either side of the scratch mark. Cut edges of galvanized surfaces where hot-dip galvanized sheet steel is used shall be coated with a zinc-rich coating conforming to ASTM D 520, Type I.

2.12.2 Field Painting

Painting required for surfaces not otherwise specified, and finish painting of items only primed at the factory are specified in Section 09900 PAINTING, GENERAL.

2.12.2.1 Color Coding

****
NOTE: Color coding for piping identification required by the using agency will be developed and inserted in the "Color Code Schedule" in Section 09900 PAINTING, GENERAL. For Air Force Installations, piping will be color-coded in accordance with Attachment 4 of AFM 88-15.
****

Color coding for piping identification is specified in Section 09900 PAINTING, GENERAL.

2.12.2.2 Color Coding Scheme

****
NOTE: Color Coding Scheme may be deleted in accordance with Notes in Section 15400 PLUMBING, GENERAL PURPOSE.
****

A color coding scheme for locating hidden piping shall be in accordance with [Section 15400 PLUMBING, GENERAL PURPOSE] [Section 15405 PLUMBING, HOSPITAL].

2.13 FACTORY TESTS

2.13.1 Chiller Performance Test

****

NOTE: In order to ensure that liquid chillers meet the capacity and efficiencies specified, factory testing will be specified on all units between 1054 and 5622 kW (300 and 1600 tons). Tests may be specified for smaller chillers in critical applications where the tests are felt justified. The ARI testing of chillers allows a deviation to chiller capacity of up to 5% at full load. Load calculations should consider this tolerance.

****

The Contractor and proposed chiller manufacturer shall be responsible for performing the chiller factory test to validate the specified full load capacity, full load EER, and [IPLV] [APLV] in accordance with ARI 550 except as indicated. [The chiller factory test shall be performed in the presence of a Government representative.] The Contractor and chiller manufacturer shall provide to the Government a certified chiller factory test report in accordance with ARI 550 to confirm that the chiller performs as specified. All tests shall be conducted in an ARI certified test facility in conformance with ARI 550 procedures and tolerances, except as indicated. At a minimum, chiller capacity shall be validated to meet the scheduled requirements indicated on the drawings. Tolerance or deviation shall be in strict accordance with ARI 550.Stable operation at minimum load of 10 percent of total capacity shall be demonstrated during the factory test.

a. Temperature adjustments shall adhere to ARI 550 to adjust from the design fouling factor to the clean tube condition. Test temperature adjustments shall be verified prior to testing by the manufacturer. There shall be no exceptions to conducting the test with clean tubes with the temperature adjustments per section A7.3 of ARI 550. The manufacturer shall clean the tubes, if necessary, prior to testing to obtain a test fouling factor of 0.0000.

b. The factory test instrumentation shall be per ARI 550 and the calibration shall be traceable to the National Institute of Standards and Technology.

c. A certified test report of all data shall be forwarded to the Government for approval prior to project acceptance. All calibration curves and information sheets for all instrumentation shall be provided.

d. If the equipment fails to perform within allowable tolerances, the

manufacturer shall be allowed to make necessary revisions to his equipment and retest as required. [The manufacturer shall assume all expenses incurred by the Government to witness the retest.]

2.13.2 Chiller Sound Test

****
NOTE: Include factory sound test requirements in applications where chiller sound level is a critical requirement. Select 85 decibels if military personnel (90 decibels for civilian personnel) will operate the equipment without hearing protection. Other decibel requirements may be specified if hearing protection is provided.
****

All centrifugal chillers shall be sound tested at the factory prior to shipment to confirm the sound pressure level specified below. All tests and data shall be conducted and measured in strict accordance with ARI 575. The centrifugal chiller sound pressure level, in decibels (dB), with a reference pressure of 20 micropascals, shall not exceed [85] [90] [_____] dB, A weighted, at full load. All ratings shall be in accordance with ARI 575. No reduction of entering condenser water temperature or raising of leaving chilled water temperature shall be allowed. A minimum of 75 percent of the sound data points shall be taken along the length of the machine, and established as the minimum percentage of total possible points used to determine sound levels. In the event that the chiller does not meet the dBA sound pressure level, the manufacturer shall, at his expense, provide sufficient attenuation to the machine to meet the specified value. This attenuation shall be applied in such a manner that it does not hinder the operation or routine maintenance procedures of the chiller. The attenuation material, adhesives, coatings, and other accessories shall have surface burning characteristics as determined by ASTM E 84.

2.14 SUPPLEMENTAL COMPONENTS/SERVICES

2.14.1 Drain and Makeup Water Piping

****
NOTE: All drain and makeup water piping should be indicated on the drawings.
****

Piping and backflow preventers shall comply with the requirements of Section 15400 PLUMBING, GENERAL PURPOSE. Drains which connect to sanitary sewer system shall be connected by means of an indirect waste.

2.14.2 Steam Piping and Accessories

Steam piping and accessories shall be provided and installed in accordance with Section 15569 WATER AND STEAM HEATING; OIL, GAS OR BOTH; UP TO 20 MBTUH.

PART 3 EXECUTION

3.1 INSTALLATION

All work shall be performed in accordance with the manufacturer's published diagrams, recommendations, and equipment warranty requirements. Where equipment is specified to conform to the requirements of ASME BPV VIII Div 1 and ASME BPV IX, the design, fabrication, and installation of the system shall conform to ASME BPV VIII Div 1 and ASME BPV IX.

3.1.1 Refrigeration System

3.1.1.1 Equipment

****

NOTE: Designer will determine in the initial stages of design the approximate distances required for maintenance clearances of all new equipment. The maintenance clearances will be used in determining the final layout of the equipment.

For installations where noise and vibration transmission to the building must be reduced, the maximum tolerable transmissibility, in percent, should be determined and the blank filled in with the appropriate value. When it is not necessary to specify the percent of transmissibility, the item in the brackets will be deleted and brackets removed. Recommended transmissibility in percentages are: 10 percent for equipment mounted in very critical areas; 10 to 20 percent for critical areas; and 20 to 40 percent for noncritical areas. The drawings should be checked to ensure that all structural and equipment connection factors and the conditions surrounding the equipment to be provided with the vibration isolation units favorably influence the effectiveness of the isolators. Where many items of equipment require different transmission values, based on the equipment location, the specification may be revised to indicate the appropriate values on the drawings.

****

Necessary supports shall be provided for all equipment, appurtenances, and pipe as required, including frames or supports for compressors, pumps, cooling towers, condensers, liquid coolers, and similar items. Compressors shall be isolated from the building structure. If mechanical vibration isolators are not provided, vibration absorbing foundations shall be provided. Each foundation shall include isolation units consisting of machine and floor or foundation fastenings, together with intermediate isolation material. Other floor-mounted equipment shall be set on not less than a 150 mm 6 inch concrete pad doweled in place. Concrete foundations for floor mounted pumps shall have a mass equivalent to three times the weight of the components, pump, base plate, and motor to be supported. In lieu of concrete pad foundation, concrete pedestal block with isolators

placed between the pedestal block and the floor may be provided. Concrete pedestal block shall be of mass not less than three times the combined pump, motor, and base weights. Isolators shall be selected and sized based on load-bearing requirements and the lowest frequency of vibration to be isolated. Isolators shall limit vibration to [_____] percent at lowest equipment rpm. Lines connected to pumps mounted on pedestal blocks shall be provided with flexible connectors. Foundation drawings, bolt-setting information, and foundation bolts shall be furnished prior to concrete foundation construction for all equipment indicated or required to have concrete foundations. Concrete for foundations and concrete-structured or cased-cooling towers shall be as specified in Section 03300 CAST-IN-PLACE STRUCTURAL CONCRETE. Equipment shall be properly leveled, aligned, and secured in place in accordance with manufacturer's instructions.

3.1.1.2 Refrigerant Charging

a. Initial Charge: Upon completion of all the refrigerant pipe tests, the vacuum on the system shall be broken by adding the required charge of dry refrigerant for which the system is designed, in accordance with the manufacturer's recommendations. Contractor shall provide the complete charge of refrigerant in accordance with manufacturer's recommendations. Upon satisfactory completion of the system performance tests, any refrigerant that has been lost from the system shall be replaced. After the system is fully operational, service valve seal caps and blanks over gauge points shall be installed and tightened.

b. Refrigerant Leakage: If a refrigerant leak is discovered after the system has been charged, the leaking portion of the system shall immediately be isolated from the remainder of the system and the refrigerant shall be pumped into the system receiver or other suitable container. The refrigerant shall not be discharged into the atmosphere.

c. Contractor's Responsibility: The Contractor shall, at all times during the installation and testing of the refrigeration system, take steps to prevent the release of refrigerants into the atmosphere. The steps shall include, but not be limited to, procedures which will minimize the release of refrigerants to the atmosphere and the use of refrigerant recovery devices to remove refrigerant from the system and store the refrigerant for reuse or reclaim. At no time shall more than 85 g 3 oz. of refrigerant be released to the atmosphere in any one occurrence. Any system leaks within the first year shall be repaired in accordance with the specified requirements including material, labor, and refrigerant if the leak is the result of defective equipment, material, or installation.

3.1.1.3 Oil Charging

Except for factory sealed units, two complete charges of lubricating oil for each compressor crankcase shall be furnished. One charge shall be used during the performance testing period, and upon the satisfactory completion of the tests, the oil shall be drained and replaced with the second charge.

3.1.1.4 Automatic Controls

****

NOTE: Change paragraph as required to coordinate the central equipment controls with the air-side system controls. In projects where this section of the specifications is intended to produce control equipment for existing air-side systems, this paragraph will be rewritten to secure controls to match existing controls and to properly integrate the specified controls into the existing temperature control system. Designer will be required to put a sequence of control for each cooling tower fan, chilled water pump, condenser water pump, etc. on the contract drawings.

****

Automatic controls for the central refrigeration system specified in paragraph REFRIGERATION SYSTEM shall be provided with the central refrigeration equipment. These controls shall operate automatically to balance the equipment capacity with the load on the air conditioning system, and shall be fully coordinated with and integrated [into the temperature control system specified in Section 15895 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM and 15950 HEATING, VENTILATING AND AIR CONDITIONING (HVAC) CONTROL SYSTEMS] [into the existing air-conditioning system].

3.1.2 General Piping Installation

3.1.2.1 Brazed Joints

Before brazing copper joints, both the outside of the tube and the inside of the fitting shall be cleaned with a wire fitting brush until the entire joint surface is bright and clean. Brazing flux shall not be used. Surplus brazing material shall be removed at all joints. Steel tubing joints shall be made in accordance with the manufacturer's recommendations. Joints in steel tubing shall be painted with the same material as the baked-on coating within 8 hours after joints are made. Tubing shall be protected against oxidation during brazing by continuous purging of the inside of the piping using nitrogen. All piping shall be supported prior to brazing and shall not be sprung or forced.

3.1.2.2 Threaded Joints

Threaded joints shall be made with tapered threads and made tight with PTFE tape complying with ASTM D 3308 or equivalent thread-joint compound applied to the male threads only. Not more than three threads shall show after the joint is made.

3.1.2.3 Welded Joints

****

NOTE: The first set of brackets shall be deleted

when more stringent requirements for weldments exist, otherwise delete the third set. Retain the second set only when required for structural members.
****

[Welding shall be in accordance with qualified procedures using qualified welders and welding operators. Procedures and welders shall be qualified in accordance with ASME BPV IX. Welding procedures qualified by others, and welders and welding operators qualified by another employer may be accepted as permitted by ASME B31.1. Contracting Officer shall be notified 24 hours in advance of welding tests and the tests shall be performed at the work site if practical. A permanent mark shall be applied near each weld to identify the welder who made that weld.] [Structural members shall be welded in accordance with Section 05055 WELDING, STRUCTURAL.] [Welding and nondestructive testing procedures are specified in Section 05093 WELDING PRESSURE PIPING.] Welded joints in steel refrigerant piping shall be fusion-welded. Changes in direction of piping shall be made with welded fittings only; mitering or notching pipe or other similar construction to form elbows or tees will not be permitted. Branch connections shall be made with welding tees or forged welding branch outlets. Steel pipe shall be thoroughly cleaned of all scale and foreign matter before the piping is assembled. During welding the pipe and fittings shall be filled with an inert gas, such as nitrogen, to prevent the formation of scale. Beveling, alignment, heat treatment, and inspection of weld shall conform to ASME B31.1. Weld defects shall be removed and rewelded at no additional cost to the Government. Electrodes shall be stored and dried in accordance with AWS D1.1 or as recommended by the manufacturer. Electrodes that have been wetted or that have lost any of their coating shall not be used.

3.1.2.4 Flanged Joints

Flanged joints shall be faced true, provided with gaskets suitable for use with refrigerants and made square and tight. When steel refrigerant piping is used, union or flange joints shall be provided in each line immediately preceding the connection to each piece of equipment requiring maintenance, such as compressors, coils, chillers, control valves, and other similar items.

3.1.2.5 Flared Connections

When flared connections are used, a suitable lubricant shall be used between the back of the flare and the nut in order to avoid tearing the flare while tightening the nut.

3.1.2.6 Thermometers

Thermometers shall be located specifically on, but not limited to the following: [condenser water lines entering and leaving the condenser] [the sensing element of each automatic temperature control device where a thermometer is not an integral part thereof] [the liquid line leaving receiver] [and] [the suction line at each evaporator or liquid cooler].

3.1.2.7 Supports

****
NOTE: Provide seismic details, if a Government designer (either Corps office of A/E) is the Engineer of Record, and show on the drawings. Delete the bracketed phrase in item b. if no seismic details are provided. Sections 13080 and 15070, properly edited, must be included in the contract documents.
****

a. General: All refrigerant pipe supports shall be in accordance with ASME B31.5. Hangers used to support piping 50 mm (2 inches) 2 inches and larger shall be fabricated to permit adequate adjustment after erection while still supporting the load. Pipe guides and anchors shall be installed to keep pipes in accurate alignment, to direct the expansion movement, and to prevent buckling, swaying, and undue strain. Piping subjected to vertical movement, when operating temperatures exceed ambient temperatures, shall be supported by variable spring hangers and supports or by constant support hangers.

b. Seismic Requirements: All piping and attached valves shall be supported and braced to resist seismic loads as specified under Sections 13080 SEISMIC PROTECTION FOR MILCELLANEOUS EQUIPMENT and 15070 SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT [as shown on the drawings]. Structural steel required for reinforcement to properly support piping, headers, and equipment but not shown shall be provided under this section. Material used for support shall be as specified under Section 05120 STRUCTURAL STEEL.

c. Structural Attachments: Structural steel brackets required to support piping, headers, and equipment, but not shown, shall be provided under this section. Material and installation shall be as specified under Section 05120 STRUCTURAL STEEL.

3.1.2.8 Pipe Hangers, Inserts, and Supports

Pipe hangers, inserts, and supports shall conform to MSS SP-58 and MSS SP-69, except as modified herein. Pipe hanger types 5, 12, and 26 shall not be used.

a. Hangers: Type 3 shall not be used on insulated piping.

b. Inserts: Type 18 inserts shall be secured to concrete forms before concrete is placed. Continuous inserts which allow more adjustments may be used if they otherwise meet the requirements for Type 18 inserts.

c. C-Clamps: Type 19 and 23 C-clamps shall be torqued per MSS SP-69 and have both locknuts and retaining devices, furnished by the manufacturer. Field-fabricated C-clamp bodies or retaining devices are not acceptable.

d. Angle Attachments: Type 20 attachments used on angles and

channels shall be furnished with an added malleable-iron heel plate or adapter.

e. Hangers: Type 24 may be used only on trapeze hanger systems or on fabricated frames.

f. Saddles and Shields: Where Type 39 saddle or Type 40 shield are permitted for a particular pipe attachment application, the Type 39 saddle, connected to the pipe, shall be used on all pipe 100 mm (4 inches) 4 inches and larger when the temperature of the medium is 16 degrees C 60 degrees F or higher. Type 40 shields shall be used on all piping less than 100 mm (4 inches) 4 inches and all piping 100 mm (4 inches) 4 inches and larger carrying medium less than 16 degrees C.60 degrees F. A high density insulation insert of cellular glass shall be used under the Type 40 shield for piping 50 mm (2 inches) 2 inches and larger.

g. Horizontal Pipe Supports: Horizontal pipe supports shall be spaced as specified in MSS SP-69 and a support shall be installed not over 300 mm 1 foot from the pipe fitting joint at each change in direction of the piping. Pipe supports shall be spaced not over 1.5 m 5 feet apart at valves. [Pipe hanger loads suspended from steel joist with hanger loads between panel points in excess of 22 kg 50 pounds shall have the excess hanger loads suspended from panel points.]

h. Vertical Pipe Supports: Vertical pipe shall be supported at each floor, except at slab-on-grade, and at intervals of not more than 4.5 m, 15 feet, not more than 2.4 m 8 feet from end of risers, and at vent terminations.

i. Pipe Guides: Type 35 guides using, steel, reinforced polytetrafluoroethylene (PTFE) or graphite slides shall be provided where required to allow longitudinal pipe movement. Lateral restraints shall be provided as required. Slide materials shall be suitable for the system operating temperatures, atmospheric conditions, and bearing loads encountered.

j. Steel Slides: Where steel slides do not require provisions for restraint of lateral movement, an alternate guide method may be used. On piping 100 mm (4 inches) 4 inches and larger, a Type 39 saddle shall be used. On piping under 100 mm (4 inches), 4 inches, a Type 40 protection shield may be attached to the pipe or insulation and freely rest on a steel slide plate.

k. High Temperature Guides with Cradles: Where there are high system temperatures and welding to piping is not desirable, then the Type 35 guide shall include a pipe cradle, welded to the guide structure and strapped securely to the pipe. The pipe shall be separated from the slide material by at least 100 mm, 4 inches, or by an amount adequate for the insulation, whichever is greater.

l. Multiple Pipe Runs: In the support of multiple pipe runs on a common base member, a clip or clamp shall be used where each pipe

crosses the base support member. Spacing of the base support members shall not exceed the hanger and support spacing required for an individual pipe in the multiple pipe run.

3.1.2.9 Pipe Alignment Guides

Pipe alignment guides shall be provided where indicated for expansion loops, offsets, and bends and as recommended by the manufacturer for expansion joints, not to exceed 1.5 m 5 feet on each side of each expansion joint, and in lines 100 mm (4 inches) 4 inches or smaller not more than 600 mm 2 feet on each side of the joint.

3.1.2.10 Anchors

Anchors shall be provided wherever necessary or indicated to localize expansion or to prevent undue strain on piping. Anchors shall consist of heavy steel collars with lugs and bolts for clamping and attaching anchor braces, unless otherwise indicated. Anchor braces shall be installed in the most effective manner to secure the desired results using turnbuckles where required. Supports, anchors, or stays shall not be attached where they will injure the structure or adjacent construction during installation or by the weight of expansion of the pipeline. Detailed drawings of pipe anchors shall be submitted for approval before installation.

3.1.2.11 Pipe Sleeves

Sleeves shall not be installed in structural members except where indicated or approved. Rectangular and square openings shall be as detailed. Each sleeve shall extend through its respective wall, floor, or roof, and shall be cut flush with each surface. Pipes passing through concrete or masonry wall or concrete floors or roofs shall be provided with pipe sleeves fitted into place at the time of construction. Unless otherwise indicated, sleeves shall be of such size as to provide a minimum of 6 mm 1/4 inch all-around clearance between bare pipe and sleeves or between jacketed-insulation and sleeves. Sleeves in bearing walls, waterproofing membrane floors, and wet areas shall be steel pipe or cast iron pipe. Sleeves in non-bearing walls, floors, or ceilings may be steel pipe, cast iron pipe, galvanized sheet metal with lock-type longitudinal seam and of the metal thickness indicated, or moisture resistant fiber or plastic. Except in pipe chases or interior walls, the annular space between pipe and sleeve or between jacket over-insulation and sleeve shall be sealed as indicated and specified in Section 07900 JOINT SEALING. Pipes passing through wall waterproofing membrane shall be sleeved as specified above, and a waterproofing clamping flange shall be installed.

a. Roof and Floor Penetrations: Pipes passing through roof or floor waterproofing membrane shall be installed through a 5.17 kg/sq. m. (17 ounce) 17 ounce copper sleeve, or a 0.81 mm (0.032 inch) 0.032 inch thick aluminum sleeve, each within an integral skirt or flange. Flashing sleeve shall be suitably formed, and skirt or flange shall extend not less than 200 mm 8 inches from the pipe and shall be set over the roof or floor membrane in a troweled coating of bituminous cement. The flashing sleeve shall extend up the pipe a minimum of 50 mm 2 inches above highest floor level of

the roof or a minimum of 250 mm 10 inches above the roof, whichever is greater, or 250 mm 10 inches above the floor. The annular space between the flashing sleeve and the bare pipe or between the flashing sleeve and the metal-jacket-covered insulation shall be sealed as indicated. Pipes up to and including 250 mm (10 inches) 10 inches in diameter passing through roof or floor waterproofing membrane may be installed through a cast iron sleeve with caulking recess, anchor lugs, flashing clamp device, and pressure ring with brass bolts. Waterproofing membrane shall be clamped into place and sealant shall be placed in the caulking recess. In lieu of a waterproofing clamping flange and caulking and sealing of annular space between pipe and sleeve or conduit and sleeve, a modular mechanical type sealing assembly may be installed. Seals shall consist of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe/conduit and sleeve with corrosion protected carbon steel bolts, nuts, and pressure plates. Links shall be loosely assembled with bolts to form a continuous rubber belt around the pipe with a pressure plate under each bolt head and each nut. After the seal assembly is properly positioned in the sleeve, tightening of the bolt shall cause the rubber sealing elements to expand and provide a watertight seal between the pipe/conduit seal between the pipe/conduit and the sleeve. Each seal assembly shall be sized as recommended by the manufacturer to fit the pipe/conduit and sleeve involved. The Contractor electing to use the modular mechanical type seals shall provide sleeves of the proper diameters.

b. Fire-Rated Walls and Partitions: Penetration of fire-rated walls and partitions shall be sealed as specified in Section 07840 FIRESTOPPING.

3.1.2.12 Escutcheons

Finished surfaces where exposed piping, bare or insulated, pass through floors, walls, or ceilings, except in boiler, utility, or equipment rooms, shall be provided with escutcheons. Where sleeves project slightly from floors, special deep-type escutcheons shall be used. Escutcheon shall be secured to pipe or pipe covering.

3.1.2.13 Access Panels

Access panels shall be provided for all concealed valves, vents, controls, and items requiring inspection or maintenance. Access panels shall be of sufficient size and located so that the concealed items may be serviced and maintained or completely removed and replaced. Access panels shall be as specified in Section 05500 MISCELLANEOUS METALS.

3.1.3 Water Piping

Pipe and fitting installation shall conform to the requirements of ASME B31.1. Pipe shall be cut accurately to measurements established at the jobsite, and worked into place without springing or forcing, completely clearing all windows, doors, and other openings. Cutting or other

weakening of the building structure to facilitate piping installation will not be permitted without written approval. Pipe or tubing shall be cut square, shall have burrs removed by reaming, and shall permit free expansion and contraction without causing damage to the building structure, pipe, joints, or hangers.

3.1.3.1 Directional Changes

Changes in direction shall be made with fittings, except that bending of pipe 100 mm (4 inches) 4 inches and smaller will be permitted, provided a pipe bender is used and wide weep bends are formed. The centerline radius of bends shall not be less than 6 diameters of the pipe. Bent pipe showing kinks, wrinkles, flattening, or other malformations will not be accepted.

3.1.3.2 Functional Requirements

Horizontal supply mains shall pitch down in the direction of flow as indicated. The grade shall not be less than 2 mm in 1 m.1 inch in 40 feet. Reducing fittings shall be used for changes in pipe sizes. Open ends of pipelines and equipment shall be capped or plugged during installation to keep dirt or other foreign materials out of the system. Pipe not otherwise specified shall be uncoated. Connections to appliances shall be made with malleable iron unions for steel pipe 65 mm (2-1/2 inches) 2-1/2 inches or less in diameter, and with flanges for pipe 80 mm (3 inches) 3 inches and above in diameter. Connections between ferrous and copper piping shall be electrically isolated from each other with dielectric unions or flanges. All piping located in air plenums shall conform to NFPA 90A requirements. Pipe and fittings installed in inaccessible conduits or trenches under concrete floor slabs shall be welded.

3.1.3.3 Valves

Isolation gate or ball valves shall be installed on each side of each piece of equipment, at the midpoint of all looped mains, and at any other points indicated or required for draining, isolating, or sectionalizing purpose. Isolation valves may be omitted where balancing cocks are installed to provide both balancing and isolation functions. Each valve except check valves shall be identified. Valves in horizontal lines shall be installed with stems horizontal or above.

3.1.3.4 Air Vents

Air vents shall be provided at all high points, on all water coils, and where indicated to ensure adequate venting of the piping system.

3.1.3.5 Drains

Drains shall be provided at all low points and where indicated to ensure complete drainage of the piping. Drains shall be accessible, and shall consist of nipples and caps or plugged tees unless otherwise indicated.

3.1.3.6 Flexible Pipe Connectors

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NOTE: Flexible pipe connectors will be provided where required to absorb expansion and contraction, isolate vibration, absorb noise, compensate offset motion, absorb continuous flexing, and relieve equipment from piping stresses. Where flexible pipe connectors are needed to correct lateral, parallel, and angular misalignment, their use will be limited to maximum offset as recommended, in writing, by the manufacturer. Flexible pipe connectors will only be used on water piping.

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Preinsulated flexible pipe connectors shall be attached to other components in strict accordance with the latest printed instructions of the manufacturer to ensure a vapor tight joint. Hangers, when required to suspend the connectors, shall be of the type recommended by the flexible pipe connector manufacturer and shall be provided at the intervals recommended.

3.1.3.7 Flanges and Unions

Except where copper tubing is used, union or flanged joints shall be provided in each line immediately preceding the connection to each piece of equipment or material requiring maintenance such as coils, pumps, control valves, and other similar items.

3.1.3.8 Grooved Mechanical Joints

Grooves shall be prepared in accordance with the coupling manufacturer's instructions. Pipe and groove dimensions shall comply with the tolerances specified by the coupling manufacturer. The diameter of grooves made in the field shall be measured using a "go/no-go" gauge, vernier or dial caliper, or narrow-land micrometer. Groove width and dimension of groove from end of pipe shall be measured and recorded for each change in grooving tool setup to verify compliance with coupling manufacturer's tolerances.

3.1.4 Refrigeration Piping

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NOTE: Belowground refrigerant piping should be avoided if at all possible. Direct buried refrigerant piping will not be installed under any circumstances. In the event that belowground pipe routing is the only alternative, the piping will be routed through an accessible trench system (i.e. concrete, fiberglass, PVC, etc). The designer will specifically detail the trench design as well as fully detail the piping techniques necessary to accommodate oil circulation at both full and part load conditions. Oil circulation is extremely critical to the successful operation of any refrigerant system. Designers will avoid creating any oil traps within a refrigerant piping system.

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Unless otherwise specified, pipe and fittings installation shall conform to requirements of ASME B31.5. Pipe shall be cut accurately to measurement established at the jobsite and worked into place without springing or forcing. Cutting or otherwise weakening of the building structure to facilitate piping installation will not be permitted without written approval. Pipes shall be cut square, shall have burrs removed by reaming, and shall be installed in a manner to permit free expansion and contraction without damage to joints or hangers. Filings, dust, or dirt shall be wiped from interior of pipe before connections are made.

3.1.4.1 Directional Changes

Changes in direction shall be made with fittings, except that bending of pipe 100 mm (4 inches) 4 inches and smaller will be permitted, provided a pipe bender is used and wide-sweep bends are formed. The centerline radius of bends shall not be less than 6 diameters of the pipe. Bent pipe showing kinks, wrinkles, or other malformations will not be accepted.

3.1.4.2 Functional Requirements

All piping shall be installed 4 mm per m 1/2 inch per 10 feet of pipe in the direction of flow to ensure adequate oil drainage. Open ends of refrigerant lines or equipment shall be properly capped or plugged during installation to keep moisture, dirt, or other foreign material out of the system. Piping shall remain capped until installation. Equipment piping shall be in accordance with the equipment manufacturer's recommendations and the contract drawings.

3.1.4.3 Valves

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NOTE: Delete last two sentences when identification tags are not considered necessary in small projects.
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a. Stop valves shall be installed on each side of each piece of equipment such as compressors condensers, evaporators, receivers, and other similar items in multiple-unit installation, to provide partial system isolation as required for maintenance or repair. Angle and globe valves shall be installed with stems horizontal unless otherwise indicated. Ball valves shall be installed with stems positioned to facilitate operation and maintenance. All valves except check valves shall be identified with a brass or aluminum tag not less than 35 mm (1-3/8 inch) 1-3/8 inch in diameter, correctly stamped to explain the valve function, and with a number for identification. Tags shall be secured to the valve with No. 12 AWG copper wire.

b. Expansion valves shall be installed with the thermostatic expansion valve bulb located on top of the suction line when the suction line is less than 54 mm (2-1/8 inches) 2-1/8 inches in diameter and at the 4 o'clock or 8 o'clock position on lines larger than 54 mm (2-1/8 inches).2-1/8 inches. The bulb shall be

securely fastened with two clamps. The bulb shall be insulated. The bulb shall installed in a horizontal portion of the suction line, if possible, with the pigtail on the bottom. If the bulb must be installed in a vertical line, the bulb tubing shall be facing up.

3.1.4.4 Vibration Dampers

Vibration damper shall be provided in the suction and discharge lines on spring mounted compressors. Vibration dampers shall be installed parallel with the shaft of the compressor and shall be anchored firmly at the upstream end on the suction line and the downstream end in the discharge line.

3.1.4.5 Strainers

Strainers shall be provided immediately ahead of all solenoid valves and expansion devices. Strainers may be an integral part of the expansion valve.

3.1.4.6 Filter Dryer

A liquid line filter dryer shall be provided on each refrigerant circuit located such that all liquid refrigerant passes through a filter dryer. The filter dryer shall be sized in accordance with the manufacturer's recommendations for the system in which it is installed. The filter dryer shall be installed such that the filter dryer can be isolated from the system, the isolated portion of the system evacuated, and the filter dryer replaced. Filter dryers shall be installed in the horizontal position except replaceable core filter dryers may be installed in the vertical position with the access flange on the bottom.

3.1.4.7 Sight Glass

A moisture indicating sight glass shall be installed in all refrigerant circuits down stream of all filter dryers.

3.1.4.8 Discharge Line Oil Separator

Discharge line oil separator shall be provided in the discharge line from each compressor. Oil return line shall be connected to the compressor as recommended by the compressor manufacturer.

3.1.4.9 Accumulator

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NOTE: Suction line accumulator should be included under certain split system applications, such as having extended refrigerant lines, 15 m (50 feet) or longer. If accumulator is not used then delete this paragraph.

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Accumulators shall be provided in the suction line to each compressor.

3.1.5 Mechanical Room Ventilation

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For mechanical rooms which are intended to house refrigeration equipment, designers will use ASHRAE 15 to determine applicable design criteria. Delete this paragraph if a mechanical room is not applicable to the design.

In summary, ASHRAE 15 allows the use of either natural or mechanical ventilation systems, however natural ventilation is allowed only in certain limited applications. Natural ventilation is allowed only when "a refrigerant system is located outdoors more than 6.1 m (20 feet) from building openings and is enclosed by a penthouse, lean-to or other open structure", otherwise mechanical ventilation is required.

The amount of ventilation air required for a mechanical room will be determined based upon the ventilation equations in ASHRAE 15. In order to use these equations, a designer must approximate the mass of refrigerant kgs or lbs expected in the largest system located in the mechanical room. Refrigerant quantities will be determined based upon a minimum of 2 different system manufacturers.

a. For a natural ventilation system, ASHRAE 15 provides an equation for sizing the amount of free opening area required.

b. For a mechanical ventilation system, ASHRAE 15 requires both normal and alarm ventilation. Normal ventilation will be sized to cover personnel ventilation requirements 2.5 1/s/m2 or (0.5 cfm/ft2) and heat buildup requirements if applicable. Alarm ventilation will be sized based upon the equations in ASHRAE 15. Both the normal and alarm ventilation rates can be achieved using the same ventilation system (e.g., multi-speed exhaust fans), however, individual systems are preferred. For the alarm ventilation, exhaust intakes will be located near the equipment and close to the finished floor. Most commonly used refrigerants are heavier-than-air and subsequently sink to the floor. Also per ASHRAE 15, air supply and exhaust ducts to the mechanical room will serve no other area within a facility. Discharge air from a mechanical ventilation system will be to the outdoors.

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Mechanical ventilation systems shall be in accordance with Section 15895

AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM.

3.1.6 Field Applied Insulation

Field applied insulation other than that specified for water boxes and headers shall be as specified in Section 15080 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

3.1.7 Factory Applied Insulation

3.1.7.1 Refrigerant Suction Lines

[Refrigerant suction lines between the cooler and each compressor [and cold gas inlet connections to gas cooled motors]] [Refrigerant pumps and exposed chilled water lines on absorption chillers] shall be insulated with not less than 19 mm (3/4 inch) 3/4 inch thick unicellular plastic foam.

3.1.7.2 Liquid Coolers

Liquid coolers (including chilled water headers or boxes), which may have factory or field applied insulation, shall be insulated with unicellular plastic foam. Insulation shall be not less than 19 mm (3/4 inch) 3/4 inch thick or have a maximum thermal conductivity of 1.59 W/((sq. m)(degree K) (0.28 Btu/((hr.)(sq. ft.)(degree F.))).0.28 Btu/(hr.)(sq. ft.)(degree F.))). In lieu of the above insulation, a 50 mm 2 inch thickness of urethane foam may be used. Urethane foam shall be completely covered and sealed with a sheet metal jacket not lighter than 1.0 mm (20 gauge).20 gauge. Insulation on heads of coolers shall be constructed to provide easy removal and replacement of heads without damage to the insulation.

3.2 TESTS

3.2.1 Field Tests

Tests shall be conducted in the presence of the Contracting Officer. Water and electricity required for the tests will be furnished by the Government. Any material, equipment, instruments, and personnel required for the test shall be provided by the Contractor. The services of a qualified technician shall be provided as required to perform all tests and procedures indicated herein. Field tests shall be coordinated with Section 15990 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS.

3.2.1.1 Water Pipe Testing

After cleaning, water piping shall be hydrostatically tested at a pressure equal to 150 percent of the total system operating pressure for period of time sufficient to inspect every joint in the system and in no case less than 2 hours. Leaks shall be repaired and piping retested until test is successful. No loss of pressure shall be allowed. Leaks shall be repaired by rewelding or replacing pipe or fittings. Caulking of joints will not be permitted. Concealed and insulated piping shall be tested in place before concealing.

3.2.1.2 Test of Backflow Prevention Assemblies

Backflow prevention assemblies shall be tested in accordance with Section 15400 PLUMBING, GENERAL PURPOSE.

3.2.1.3 Refrigerant Pipe Testing

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NOTE: Where applicable condensing temperature is over 54 degrees C (130 degrees F), equipment and piping will be capable of withstanding leak pressure tests at not less than the design pressure corresponding to the condensing pressure during the higher ambient conditions. (Refer to ASHRAE 15.)

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a. Refrigerant Leakage Test: After all components of the refrigerant system have been installed and the piping connected, the system shall be subjected to a refrigerant leakage test. The refrigerant leakage test shall be done with dry nitrogen before any refrigerant pipe is insulated or covered. High and low side of the refrigerant system shall be tested for the minimum refrigerant leakage test pressure specified in ASHRAE 15, for the refrigerant employed in the system. System shall be proved tight and free of leaks by allowing the refrigerant leakage test pressure to remain on the system for 24 hours with no drop in pressure. The initial test pressure and surrounding air temperature will be recorded. After the 24 hour hold period, the final system pressure and surrounding air temperature will be recorded. A correction of 3.7 kPa 0.3 psi shall be allowed for each degree C F change in the initial and final temperature of the surrounding air, plus for an increase and minus for a decrease. The system shall have passed the refrigerant leakage test if the corrected final system pressure is equal to the initial system test pressure. If the pressures are not equal, the leaks shall be located and repaired.

b. Refrigerant Leaks: To repair leaks, the joint shall be taken apart, thoroughly cleaned, and remade as a new joint. Joints repaired by caulking or remelting and adding more brazing material will not be acceptable. After leak repairs have been made, the refrigerant leakage test shall be conducted again.

c. Evacuation Test: After the foregoing tests have been satisfactorily completed and the pressure relieved, entire system shall be evacuated to an absolute pressure of 300 microns. During evacuation of the system, the ambient temperature shall be higher than 2 degrees C.35 degrees F. Vacuum line shall be closed, and the system shall stand for 1 hour. After this period, the absolute pressure shall not exceed 500 microns. If the pressure rises over 500 microns, the system shall continue to be evacuated until the system reaches 300 microns and can stand for 1 hour with the vacuum line closed without the absolute pressure rising over 500 microns. During evacuation, pressures shall be recorded by a thermocouple type, electronic type, or a calibrated-micron type gauge.

3.2.1.4 Cooling Tower Tests

After cooling tower has been found acceptable under the visual and dimensional examination, a field performance test shall be performed in accordance with ASME PTC 23 or CTI ATC-105. The [electromagnetic interference suppression test] [and the] [salt spray test is not required]. The cooling tower test shall be performed in the presence of a Government representative.

3.2.2 System Performance Tests

After the foregoing tests have been completed and before each refrigeration system is accepted, tests to demonstrate the general operating characteristics of all equipment shall be conducted by a registered professional engineer or an approved manufacturer's startup representative experienced in system startup and testing, at such times as directed. Tests shall cover a period of not less than [_____] days for each system and shall demonstrate that the entire system is functioning in accordance with the drawings and specifications. Corrections and adjustments shall be made as necessary and tests shall be re-conducted to demonstrate that the entire system is functioning as specified.

3.2.3 Condenser Water Quality Tests

The condenser water shall be analyzed a minimum of once a month for a period of one year by the water treatment company. The analysis shall include the following information recorded in accordance with ASTM D 596.

Date of Sample	_____	
Temperature	_____	degrees C.
Silica (SiO2)	_____	ppm (mg/1)
Insoluble	_____	ppm (mg/1)
Iron and Aluminum Oxides	_____	ppm (mg/1)
Calcium (Ca)	_____	ppm (mg/1)
Magnesium (Mg)	_____	ppm (mg/1)
Sodium and Potassium (Na and K)	_____	ppm (mg/1)
Carbonate (HCO3)	_____	ppm (mg/1)
Sulfate (SO4)	_____	ppm (mg/1)
Chloride (Cl)	_____	ppm (mg/1)
Nitrate (NO3)	_____	ppm (mg/1)
Turbidity	_____	unit
pH	_____	
Residual Chlorine	_____	ppm (mg/1)
Total Alkalinity	_____	epm (meq/1)
Non-Carbonate Hardness	_____	epm (meq/1)
Total Hardness	_____	epm (meq/1)
Dissolved Solids	_____	ppm (mg/1)
Fluorine	_____	ppm (mg/1)
Conductivity	_____	micrmho/cm

Date of Sample	_____	
Temperature	_____	degrees F.
Silica (SiO2)	_____	ppm (mg/1)

Insoluble	_____ ppm (mg/1)
Iron and Aluminum Oxides	_____ ppm (mg/1)
Calcium (Ca)	_____ ppm (mg/1)
Magnesium (Mg)	_____ ppm (mg/1)
Sodium and Potassium (Na and K)	_____ ppm (mg/1)
Carbonate (HCO3)	_____ ppm (mg/1)
Sulfate (SO4)	_____ ppm (mg/1)
Chloride (Cl)	_____ ppm (mg/1)
Nitrate (NO3)	_____ ppm (mg/1)
Turbidity	_____ unit
pH	_____
Residual Chlorine	_____ ppm (mg/1)
Total Alkalinity	_____ epm (meq/1)
Non-Carbonate Hardness	_____ epm (meq/1)
Total Hardness	_____ epm (meq/1)
Dissolved Solids	_____ ppm (mg/1)
Fluorine	_____ ppm (mg/1)
Conductivity	_____ micrmho/cm

3.3 INSPECTIONS

At the conclusion of the one year period, the cooling tower and condenser shall be inspected for problems due to corrosion, scale, and biological growth. If the cooling tower and condenser are found not to conform to the manufacturers recommended conditions, and the water treatment company recommendations have been followed; the water treatment company shall provide all chemicals and labor for cleaning or repairing the equipment as required by the manufacturer's recommendations.

3.4 MANUFACTURER'S FIELD SERVICE

The services of a factory-trained representative shall be provided for [_____] days. The representative shall advise on the following:

a. Hermetic machines:

(1) Testing hermetic water-chilling unit under pressure for refrigerant leaks; evacuation and dehydration of machine to an absolute pressure of not over 300 microns.

(2) Charging the machine with refrigerant.

(3) Starting the machine.

b. Open Machines:

(1) Erection, alignment, testing, and dehydrating.

(2) Charging the machine with refrigerant.

(3) Starting the machine.

c. Absorption Units:

(1) Testing and evacuation.

(2) Charging the machine with refrigerant.

(3) Starting the machine.

3.5 CLEANING AND ADJUSTING

3.5.1 Piping

Pipes shall be cleaned free of scale and thoroughly flushed of all foreign matter. A temporary bypass shall be provided for all water coils to prevent flushing water from passing through coils. Strainers and valves shall be thoroughly cleaned. Prior to testing and balancing, air shall be removed from all water systems by operating the air vents. Temporary measures, such as piping the overflow from vents to a collecting vessel shall be taken to avoid water damage during the venting process. Air vents shall be plugged or capped after the system has been vented.

3.5.2 Equipment

Equipment shall be wiped clean, with all traces of oil, dust, dirt, or paint spots removed. Temporary filters shall be provided for all fans that are operated during construction, and new filters shall be installed after all construction dirt has been removed from the building. System shall be maintained in this clean condition until final acceptance. Bearings shall be properly lubricated with oil or grease as recommended by the manufacturer. Belts shall be tightened to proper tension. Control valves and other miscellaneous equipment requiring adjustment shall be adjusted to setting indicated or directed. Fans shall be adjusted to the speed indicated by the manufacturer to meet specified conditions.

3.6 DEMONSTRATIONS

Contractor shall conduct a training course for the operating staff as designated by the Contracting Officer. The training period shall consist of a total [_____] hours of normal working time and start after the system is functionally completed but prior to final acceptance tests. The field instructions shall cover all of the items contained in the approved operation and maintenance manuals as well as demonstrations of routine maintenance operations.

-- End of Section --